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Prepared For

DEPARTMENT OF THE NAVY
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FINAL

FINAL STATUS RADIATION SURVEY AND FIELD SAMPLING WORK PLAN

ALAMEDA POINT (FORMER NAVAL AIR STATION ALAMEDA) ALAMEDA, CALIFORNIA

OCTOBER 1998

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CONTENTS

CONTENTS (Continued)

C:\CIS's Documents\Base specific Items\alameda\WrkPlnFinal rad characterization qcc ready final.doc

CONTENTS (Continued)

ABBREVIATIONS AND ACRONYMS

Bq	Becquerel
CLEAN	Comprehensive Long-Term Environmental Action - Navy
cm	Centimeter
cm^2	Square centimeter
CTO	Contract Task Order
DCGL	Derived concentration guideline limit
dpm/100 cm^2	Disintegrations per minute per 100 square centimeters
GM	Geiger-Müeller
IR	Installation restoration
KeV	Kilo electron-Volt
LC	Critical level
LD	Detection Limit
m^2	Meter squared
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDA	Minimum detectable activity
MDC	Minimum detectable concentration
MDL	Minimum detectable limit
NIST	National Institute of Standards and Technology
NRC	Nuclear Regulatory Commission
pCi	picoCurie
QAPP	Quality Assurance Project Plan
QCMP	Quality Control Management Plan
RASO	Radiological Affairs Support Office
RRATS	Radiological Removal Action Technical Specifications
RRAD	Radiological Removal Action Drawings
RAO	Remedial Action Order
RI	Remedial Investigation
SOP	Standard operating procedure
TEDE	Total effective dose equivalent
TtEMI	Tetra Tech EM Inc.
µCi	microCurie

FIGURES IN APPENDIX B

Figure

1.0 INTRODUCTION

On June 22, 1995, Tetra Tech EM Inc. (TtEMI), formerly known as PRC Environmental Management, Inc. (PRC), received Contract Task Order (CTO) No. 147 from the Naval Facilities Engineering Command, Engineering Field Activity West (EFA West) under Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract No. N62474-94-D-7609 (CLEAN II). CTO 147 directed TtEMI to prepare this final confirmation survey work plan for conducting radiological surveys at Alameda Point under Task 4 of the statement of work. This document describes the methods, techniques, and scope for field work to be performed to provide final confirmation surveys of residual radioactive contamination at several locations at Alameda Point. Subsequently, EFA West awarded CTO 239 (July 1998) directing TtEMI to conduct background soil sampling at sites 5 and 10 and to perform additional surface radiological surveys.

1.1 PURPOSE

The purpose of this work plan is to describe the field procedures and analytical methods that will be used to conduct a final status survey at various locations at Alameda Point. To the extent practicable, the final radiological survey will develop data to (1) support a recommendation by Radiological Affairs Support Office (RASO) for unrestricted (free from radiological regulatory control or claimed jurisdiction) release of the areas from radiological control, (2) document the final radiological status of the facility, and (3) provide data of sufficient detail, quantity, and quality to support the installation restoration (IR) program data requirements and permit review by oversight agencies.

This work plan describes the project scope and the detailed technical procedures that the Navy CLEAN contractor will use to survey several locations at Alameda Point, to confirm the absence of low level radioactive materials and contamination, within the limits of the methods described herein, or to identify the presence thereof, above numerical goals.

2.0 PROJECT SCOPE

As described in the "Final Technical Work Document/Removal Action Plan for Removal of Radiation Sources at Alameda Point and Final Removal Site Evaluation" (TtEMI 1998c), the Navy is undertaking a comprehensive and final (with respect to residual radioactivity) action at Alameda Point IR sites 5 and 10 such that the facilities will be suitable for release from radiological control by the Navy for unrestricted use. Previous surveys have identified areas of remaining residual activity or suspect areas (PRC 1996) for additional investigation and action. This action includes additional radiological surveys of the extent, quality, and quantity necessary to serve as final status surveys in suspect areas and in areas where removals will take place. Within Buildings 5 and 400, several wall and floor surfaces have been identified for resurvey and remediation. Surveys will be conducted to demonstrate that numerical goals have been satisfied. Surveys previously conducted in Building 400 were final status surveys (PRC 1996c). Within IR sites 5 and 10, buried pipes and sewer lines previously identified as contaminated are subject to removal in accordance with the project Radiological Removal Action Technical Specifications (RRATS) (TtEMI 1998a) and project Radiological Removal Action Drawings (RRAD) (TtEMI 1998b). Radiation surveys and sampling in the vicinity of all removed lines where the potential for leakage existed will be conducted to demonstrate numerical goals have been satisfied. All project work areas and lay-down, waste storage, and decontamination areas will be surveyed after construction is complete. In addition, a border area, 3 meters wide on the floor, will be surveyed underneath all overhead pipe removal work. At the radioactive waste storage shack area, surface soil will be sampled and tested for radioactivity above project numerical goals.

The survey work plans described herein meet or exceed the specifications of previously approved final status survey work plans (PRC 1993) and have been designed in accordance with the most current guidance in the areas of survey design, field measurement methods, data interpretation (statistical hypothesis testing), and quality assurance including that set forth in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (U.S. Environmental Protection Agency [EPA] 1997).

Detailed TtEMI procedures for performing radiological surveys and instrument calibration are attached to this work plan (Appendix A). Copies of site figures, pertinent parts of prior survey results, and other relevant reference information (forms, vendor catalog cuts, MARSSIM excerpts, etc.) are also attached to this document (Appendices B, C, and D). The detailed extent of surveys performed may be increased based on field conditions.

3.0 SITE BACKGROUND AND HISTORY

Site background information, general and specific site histories, and contaminants of concern for the sites are discussed in the following subsections.

3.1 SITE BACKGROUND

Alameda Point lies at the geographic center of San Francisco Bay, occupying the western third of Alameda Island (Figure 1). The Navy acquired the site in 1936 from the City of Alameda, and the station was commissioned in 1940. Alameda Point occupies 2,842 acres: 1,734 acres is land, and 1,108 acres consists of water and an airspace easement. Most of the land at Alameda Point was created by filling existing tidelands, marshlands, and sloughs. NAS Alameda was closed in April 1997 under the Base Realignment and Closure program.

The Navy began its investigation of Alameda Point under the Naval Assessment and Control of Installation Pollutants program in 1982. The investigation began with an initial assessment survey (IAS), which identified 12 potentially contaminated sites at Alameda Point, including the present IR Sites 1 and 2 landfills. In 1988, the State of California issued a remedial action order (RAO) requiring a remedial investigation (RI) at Alameda Point. The RAO sites included the IR Sites 1 and 2 landfills and Building 5 (IR Site 5). The Navy began RI and feasibility study investigations at Alameda Point in 1988. At that time, the Navy designated 23 IR program sites, including the three sites addressed in the RAO, Building 400 (IR Site 10), and 19 additional sites.

3.2 OPERATIONAL HISTORY

The following sections describe the operational history of the survey locations as it relates to radiological concerns. All figures and reference drawings are available in the radiation survey report (PRC 1996a) or the RRATSs (TtEMI 1998a) and RRADs (TtEMI 1998b). Pertinent figures have been included in Appendix B.

The use of radioactive materials at Alameda Point began in the 1940s in Building 5 (IR Site 5), where radioluminescent aircraft instrument dials were refurbished with radium-226. The Building 5 radium operations ended in the late 1950s to early 1960s (exact date unknown). Similar radiological refurbishing operations were conducted in Building 400 (IR Site 10) from the 1950s up to the closing of the base. After 1979, all radiological operations in Building 400 were conducted in a controlled booth and carefully monitored. Low-level radioactive waste from the radium dial operations may have been disposed of at both the IR Sites 1 and 2 landfills, and material was also disposed of at the low-level radioactive waste storage area.

3.3 CONTAMINANTS OF CONCERN

Radioactive contamination and buried radioactive materials have been identified at several locations at Alameda Point, including drain lines and landfill soils (PRC 1996a). Several other areas are suspected of being contaminated with radioactive material. The suspected radioactive contaminant of concern for this survey is radium-226. No evidence of residual strontium-90 has been identified in these areas; therefore, it is not considered a contaminant of concern. Radium-226, which has a half-life of approximately 1,600 years, decays by emission of an alpha particle, with associated gamma emissions (principally a 186 kilo electron-volt [keV] transition with a 4-percent probability for gamma emission). Radium-226 decay products (progeny), however, emit beta and gamma radiations that are more abundant and more readily detectable, although of lesser energy, thereby permitting detection of radium sources by several independent means. Radioluminescent devices typically produce gamma radiation that can be distinguished from background radiation by the survey techniques identified hereinafter if they contain enough activity and are covered by less than 10 to 30 centimeters (cm) of soil. The radium-226 progeny, lead-214 and bismuth-214, are the primary gamma-emitting radium decay products detectable from their gamma emissions.

Numerical goals for this project are based on radium-226 being present in secular equilibrium with its progeny (all progeny are assumed present at the same activity concentration as radium-226); therefore, quantitation of specific progeny is not required for demonstration of compliance with numerical goals. Where the degree of equilibrium, other than secular equilibrium, is assumed or relied upon, it is explicitly stated.

Radium-226 is a component of radioluminescent paint, which was commonly used, stored, and disposed of at Alameda Point. Radioluminescent paints are discussed further in the following text.

3.3.1 Radioluminescent Paints

These paints are a combination of phosphorescent compounds and chemically separated radium. Radium isolated from natural sources contains both radium-226 and radium-228. Because of the chemical separation process, any radium-228 present is not supported (by a longer-lived radionuclide) and is essentially absent from radium sources present at Alameda Point. The activated phosphor is produced by a supplier and mixed into a paint base by the user. The interaction of the radioactive particles with the phosphorescent compound prompts the emission of a small continuous light. This paint was used to enhance night visibility of indicator needles, knobs, gun sites, and markings on gauges, and on markers that lined the edges of ships (deck markers). These markers provided uninterrupted lighting even in the event of electrical power failures.

3.3.2 Radioluminescent Components

The dials and illuminators that may have been disposed of at IR Sites 1 and 2 can have radiation activities that range from less than 1 microcurie[1] (μCi) to 25 μCi. The Navy point of expertise on radiological matters, Naval Sea Systems Command, Detachment, RASO suggests, however, that most of the sources should have an activity on the order of about 1 μCi. In addition, these buried devices may corrode, thereby releasing radium-226 into the surrounding soil. It is possible that some soil in IR Sites 1 and 2 may contain elevated amounts of radium-226 and its progeny.

3.3.3 Previous Characterizations

To characterize radiological contamination at Alameda Point, a series of radiological surveys were conducted. Radioactive contamination was detected in piping, equipment, and building surfaces of both Buildings 5 and 400 as well as drain lines, storm sewers, manholes, and entrained sediments associated with those buildings (PRC 1996a). Radioactive anomalies (areas with elevated radioactivity of unknown origin) were detected in the IR Sites 1 and 2 landfills (Figures 1 and 2), and radium-226 sources were recovered from both sites. Based on the results of the radiological surveys, it was recommended that further investigations and removal actions be considered for the IR Site 1 landfill, IR Site 2 landfill, IR Site 5 (Building 5), IR Site 10 (Building 400), and storm sewer line F and related manholes (associated with Buildings 5 and 400). Brief descriptions of these sites and their associated radiological issues are provided in the following text.

3.3.3.1 IR Site 5 (Building 5)

IR Site 5 consists of Building 5, which was an aircraft rework facility (Figures 1 and 2). Radioluminescent paints containing radium-226 have been stored, used, or disposed of in Building 5.

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1 The microcurie is a historical unit used to define the radioactive transformation rate of any nuclide. For radium-226, one microcurie corresponds to one microgram of the isotope. The current SI [*System Internationa]l* unit for radioactivity is the Becquerel [Bq]. One microcurie (μCi) is equal to 3.7×10^4 Bq.

Site history suggests that radium-containing paints were disposed of in industrial waste sinks and possibly other plumbing fixtures in Building 5, which emptied into the storm sewer drainage system. At one time, the building drain line servicing the Bearing Shop on the second floor of Building 5 was connected directly to storm sewer line F, which empties into the Seaplane Lagoon. The drain line in Building 5 starts above the Small Parts Paint Shop, where it previously serviced several industrial waste sinks in the Bearing Shop. (The Bearing Shop is believed to have been a radium paint shop in the 1950s.) In the process of redirecting the flow of these sinks to the sanitary sewer system, the drain line was found to be contaminated with radium-226 (PRC 1996a). It is suspected that the sinks were used as a disposal location for radium-containing paint waste.

Radiological surveys revealed one area of radioactive contamination within Room 227C in Building 5. In addition, the surveys detected radioactive contamination of drain lines in Building 5 that feeds storm sewer line F. The contaminated drain lines includes both exposed and subsurface sections. The building is presently locked, and access is controlled by the Navy.

The following areas are known or suspected to contain radioactive contamination: (1) the Bearing Shop in Building 5, (2) the Small Parts Paints Shop in Building 5, and (3) the additional rooms (the RRADs provide detailed descriptions of the locations of the Bearing Shop and the Small Parts Paint Shop within Building 5 [TtEMI 1998b]). Radium dials were processed and radioluminescent paints were stored or used in some or all of these areas. The Navy CLEAN contractor will survey these areas as Class I areas after removal actions and cursory surveys (to identify the presence and extent of fixed and removable surface radium contamination) are accomplished by the removal action contractor. Any remaining equipment and fixtures in the affected rooms will also be surveyed so that they may be removed and processed accordingly. In order to perform the room surveys, which require 100 percent coverage of the floor areas and up to 2 meters in height on the walls, all floor and wall coverings will be removed. In the case of painted wall surfaces, beta-gamma surveys will be relied upon to identify radium containing materials.

The Navy CLEAN contractor will survey two stairwells and an elevator floor nearest the Bearing Shop as a Class III area (10 percent surface area coverage).

3.3.3.2 IR Site 10 (Building 400)

IR Site 10 consists of Building 400, which was a missile rework facility (Figures 1, 3, 4, and 6). Radioluminescent paint was stored, used, or disposed of in Building 400. The radiation surveys detected radioactive contamination of the surfaces of four rooms (Rooms 203, 204, 210, and 213) in Building 400. The building is presently locked, and access is controlled by the Navy.

Site history indicated radioluminescent paints were stored or used in Rooms 203, 204, 210, and 213 of Building 400. Several drain lines associated with Rooms 203, 204, and 213 are known to be connected to the industrial waste drainage system. The drain lines which have been identified for removal are shown on drawings 3 and 5 of the RRAD (TtEMI 1998b).

A final status survey was previously conducted in these rooms. Only identified hot spots and newly exposed floor areas will be resurveyed after the removal is completed.

3.3.3.3 Storm Sewers

Storm sewer line F and related manholes include portions of the sewer system leading from IR Site 5 (Building 5) and IR Site 10 (Building 400) to an outfall at the seaplane lagoon (Drawings 3 through 5, TtEMI 1998b). Portions of these sewer lines are contaminated with radioactive material. Some manhole catch basins along storm sewer line F also exhibit radioactive contamination. Access to storm sewer line F is through the associated manholes.

Storm sewer segments impacted by radioactive contamination are listed in the following table, along with the respective utility line drawing (TtEMI 1998b) and radiation survey report (PRC 1996a or NWT 1998).

Table of Line Removals

Line Designation	Reference Drawing[1]	Survey Report[2]	Activity Range (nCi)
6F-5F *	Sheet 3	1	>100,000
5F-4F *	Sheet 3	1	10-1000
4F-3F *	Sheet 3	1	10-1000
3F-2F *	Sheet 4	2	5-1800
2F-F *	Sheet 4	2	7-1250
3F-3F1 *	Sheet 4	2	4-9000
3F-3F5	Sheet 4	2	4-32
4F-4F1	Sheet 3	2	4-15
4F1-4F2	Sheet 3	2	5-60
4F2-4F3	Sheet 3	2	4-40
5F-5F1 *	Sheet 3	2	4-540
5F1-5F2	Sheet 3	2	4-20
5F2-5F3	Sheet 3	2	4-35
5F3-5F4	Sheet 3	2	5-20
6F-6F3	Sheet 3	2	7-36
6F3-6F4	Sheet 3	2	13-17
6F4-6F5	Sheet 3	2	13-17
6F-6F1 *	Sheet 3	2	13-1900
6F1-6F2 *	Sheet 3	2	90-2000
6F2-Bldg 5 *	Sheet 3	2	11-18,500
6F1-Bldg 5 *	Sheet 3	2	19-11,500
IW1-3-Bldg 400 *	Sheet 3	1	10-1000
6F2-Bldg 5 Drain *	Sheet 3,	2	108-2852

1 Sheets are from Radiological Removal Action Drawings, TtEMI 1998b

2 Survey Report 1: PRC 1996
Survey Report 2: NWT 1998
* Activity range exceeds 100 nCi

3.3.3.4 IR Site 1 Landfills

The IR Site 1 landfill final survey will be performed by another Navy contractor, and is therefore not discussed further in this report.

3.3.3.5 Site 2 Landfills

IR Site 2 landfills include the landfill and the former radioactive waste storage shack. Final survey for the IR Site 2 landfill will be performed by another Navy contractor.

A radioactive waste storage shack was located at the northwestern corner of the approximately 65-acre site, which is crossed by jogging trails. The radioactive waste storage shack was used to store radioactive waste materials. The shack was located within a 14- by 16-foot cyclone fence inside IR Site 2. A previous survey of the shack and the immediate surrounding area established the presence of radium dials buried just below the ground surface. Several near-surface radium-226 sources were also identified and removed from the former radioactive waste storage shack location. The shack was dismantled in 1995, and the building materials were disposed of off base. The fence posts remain and serve as the area boundary. The surface of the site will be surveyed by the CLEAN contractor for radiation exposure rates. The CLEAN contractor will also collect soil samples. Currently, access to the entire area has been restricted, and only environmental restoration contractors authorized by the Navy Caretaker Site Office may gain site access.

3.3.4 Background Radiation

Naturally occurring radiation sources in soils include, but are not limited to, uranium and thorium as well as their progeny and potassium-40. The soils at Alameda Point include arkosic sands, clays, and silts. The predominant source of naturally occurring radioactive isotopes in these soils is the arkosic sand fraction, which contains feldspars, a natural source of gamma-emitting potassium-40. The arkosic sand fraction may also contain some granitic rock. Granitic rock contains small amounts of uranium isotopes (principally uranium-238 and to a lesser extent uranium-235) that decay into other radioisotopes, including radium-226. Sources of natural radioactivity formed on a geologic time scale are referred to as primordial sources. All numerical criteria for radium are in addition to the background concentration.

Other important sources of background radiation in soils are manmade and are referred to as anthropogenic. As the result of tests of nuclear weapons, cesium-137 and strontium-90 are two anthropogenic radioisotopes which are ubiquitous in the environment. These materials are deposited from the atmosphere as fallout. The quantities of fallout material in soils depends on the extent of surface soil erosion or tilling since deposition, and can, therefore, vary widely from site to site. Because these radioisotopes are not associated with site activities, they will not be monitored. However, the variability of fallout may factor into background measurements.

Because radioisotopes are present in some construction materials originating from rock or soil, background radiation is also variable within buildings at Alameda Point. This background radiation will vary from building to building, depending on the type of construction materials and source that were used in construction. As part of this project, background radioactivity concentrations may be assessed in soils and construction materials.

3.4 FIELD LOCATIONS

The field locations included within the scope of this work plan include the following areas:

- Interior rooms of Building 5 and drain line routes within the floor slab after line removal
- Interior rooms of Building 400 and drain line routes within the floor slab after line removal
- Storm sewer lines listed in section 3.3.3.3 in accordance with the RRADs (TtEMI 1998b)
- Site of former radioactive waste storage shack near the IR Site 2 landfill

3.5 GENERAL SURVEY OBJECTIVES BY LOCATION

The objectives for each location are as follows:

- Building 5
  - (1) Survey rooms for surface radioactivity potentially contaminated with radium-226 (Class I or affected areas), (2) identify areas of radioactivity above project numerical goals (average or maximum limits), and (3) perform a postremediation survey.

- (1) Survey the remaining building drain lines penetrations after line removal, (2) survey potentially affected pipe routes where pipe was removed from within the concrete slab, (3) identify areas of activity which are above project numerical goals (average or maximum limits), and (4) perform a postremediation survey.
- Survey work areas, laydown areas, and decontamination zones used by each Navy contractor.

- Building 400
  - (1) Survey rooms for surface radioactivity potentially contaminated with radium-226 (Class I or affected areas), (2) identify areas of radioactivity above project numerical goals (average or maximum limits), and (3) perform a postremediation survey.
  - (1) Survey the remaining building drain lines penetrations after line removal,, (2) identify areas of radioactivity above project numerical goals (average or maximum limits), and (3) perform a postremediation survey.
  - (1) Survey the storm sewer drain line routes associated with Building 400 for radium-226 and (2) identify areas of radioactivity significantly above project numerical goals (average or maximum limits) or dose-based criteria. (For sewer pipes or other areas that cannot be accessed directly for survey, remotely operated detectors will be placed in the area. The detection systems are operated such that they are sensitive enough to identify where the dose criteria could be exceeded.)
  - Survey work areas, laydown areas, and decontamination zones used by each Navy contractor.

- Sewer Lines
  - (1) Survey and sample the storm sewer drain line routes for radium-226 and (2) identify areas of radioactivity significantly above project numerical goals (average or maximum limits) or dose-based criteria.
  - Survey work areas, laydown areas, and decontamination zones

- IR Site 2 Radioactive Waste Storage Shack Area
  - (1) Survey and (2) sample the soils to identify areas of activity significantly above project numerical goals or dose-based criteria.

4.0 RADIOLOGICAL SURVEY METHODS

This section describes the overall approach to performing the final status surveys for this project, including radiation detection methods to be used, survey design, statistical considerations, and quality control for the survey. Subsequent sections describe the detailed instrument performance characteristics and instrument operation parameters as well as the detailed survey tasks.

4.1 RADIATION DETECTION METHODS

Several radiation detection methods will be used during the radiological surveys: (1) gamma exposure rate measurements, (2) gamma detector response rate measurements, (3) fixed and removable beta-gamma activity measurements, (4) fixed and removable alpha activity measurements, (5) soil and water samples, and (6) interior drain line characterization measurements. Field survey methodology, techniques, and terminology are in general accordance with the U.S. Nuclear Regulatory Commission (NRC) guidance document "Manual for Conducting Radiological Surveys in Support of License Termination" (NRC 1992) and MARSSIM (EPA 1997). TtEMI Standard Operating Procedures (Appendix A) or EPA Standard Operating Procedures (EPA 1988) provide specific details as to how the surveys will be performed.

Background radiation levels for each detection method used at a site will be measured at appropriate unaffected locations identified within the survey area. For outside surface surveys, background measurements will be taken near the survey location in an area that is unlikely to contain any radioactive materials at activities above background levels. These background measurements will be made on the same type of surface as the survey measurements (such as soil or concrete). Background radiation levels will be established by identifying background radiation levels of rooms and pipe routes constructed of similar materials or assume that surface contribution of background is zero (which is conservative and health-protective). Background radiation concentrations for soils will be established by soil sampling, with consideration given to identification of varying radioactivity in different strata. As radium is ubiquitous in soil and a naturally occurring chemical, alpha spectroscopy analysis will be required to verify that soils selected for establishing background concentrations are not influenced by impacts from Navy activities.

For soil samples, non-parametric statistical methodologies (rank sum test) described in the MARSSIM will be utilized to compare the post-remediation site conditions with the naturally occurring background radioactivity. For surface activity measurements, the sign test will be used to demonstrate that surface residual activity criteria are satisfied.

4.2 FINAL STATUS SURVEY

The primary objectives of the final status survey are defined in the MARSSIM (EPA 1997). Each survey unit has different measurement requirements based on the types of contamination and the requirements for demonstrating the numerical goals were achieved.

4.2.1 Survey Objectives

The final objective of each survey is to demonstrate compliance with numerical goals set forth in the Final Technical Work Document/Removal Action Plan for Removal of Radiation Sources at Alameda Point and Final Removal Site Evaluation (TtEMI 1998c). For soils, this will be accomplished by a combination of scanning and sampling of soils exposed within the trench. For accessible surfaces within buildings, this will be accomplished by direct measurement of alpha and/or beta-gamma radioactivity. For buried pipelines that are otherwise inaccessible surfaces, radiation detector response will be measured and compared to a dose-based derived limit. This will be accomplished for sewer pipes or other areas that cannot be accessed directly for survey, by placing remotely operated detectors in the areas. The detection systems are operated such that they are sensitive enough to identify where the dose criteria of the TWD (15 millirems total effective dose equivalent [TEDE] per year[2]) could be exceeded.) A dose rate survey will be conducted over floor areas where inaccessible pipes are noted as a final demonstration of compliance with criteria at the completion of the project.

4.2.2 Survey Unit Classification

Survey units for this project are classified in accordance with MARSSIM (EPA 1997). This survey includes only Class I survey units, as all previous areas have either been adequately surveyed or identified as not requiring additional surveys based on area classification and site history. Where previous surveys have been deemed adequate, only the remediated areas will be resurveyed.

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[2] Assessed to the average member of the critical population group.

4.2.3 Systematic Sampling Plan

Where radiation scans cannot distinguish areas of elevated activity, soil samples will be collected from grid nodes selected by using a random number table to generate coordinates. For internal building surfaces requiring 100 percent scans, fixed measurements at grid nodes will be made; and any, areas identified with greater than 50 percent of the numerical goal on scanning will be quantified with a fixed count at the apparent highest area within the grid. Scan measurements will be reported as average and maximum detector response within a grid. Average measurements, where necessary, will be field calculated and reported as averaged.

A two-meter grid spacing will be utilized for fixed point counting. This spacing will be sufficient to demonstrate that average surface activity criteria are satisfied. The scan minimum detectable concentration will be calculated and reported for each detector in accordance with MARSSIM. The ratio of the scan minimum detectable concentration to the average surface activity limit will not exceed a factor of six. This factor is based on the indoor area factor calculated using the method described in the MARSSIM. This is discussed further in section.6.8.

4.2.4 Field Measurement Identification

All field measurements will be clearly traceable to a detector calibration record. Field measurements are identified for use with a Microsoft Access™ database designed specifically for collecting data, performing necessary calculations, and reporting field measurement data. Field measurements are identified as follows. The surveyor shall start a new field data sheet for each detector calibration case (a case is a calibrated detector and its associated data sets) and record each measurement or scan using a unique identifier that identifies the location and type of measurement. Location codes are sequential numbers developed to identify reference locations. Location codes may be assigned during the survey or established during data entry. When reporting data, the following code measurements will also be used:

•	Scan	S	Indicate maximum as SM
•	Swipe	W	W denotes exactly 100 cm2, WX may be greater area, WO | indicates entire object was swiped
•	Fixed Count	F	Code average count as FA
•	Duplicate	D	Append to type code (that is, WD, FD, SD, FAD)

Data may also be recorded directly on figures or sketches. A figure or sketch may be used to aid in location descriptions. If a series of counts are recorded on a sketch, record the starting sequential number completely (see the following text) and sequential numbers/gross count results (for example, -101/2475, -102/3128, -103/2332). (The count time is identified from the reference case and count rate computed by the database.) This numbering system will distinguish the identifier from the count. Identify measurements on sketches as follows:

- Swipes by enclosing a sequence number in a triangle -101 402
- Fixed counts by enclosing in a circle -102 374
- Scans by enclosing the average and maximum in a square with a diagonal separator (average/maximum) -103 100/140

If more than one case is recorded on a sketch, preface each reading with the unique case identifier. Thus, a typical sample may be:

A2147[-223/2986FA]

where:

- A2 is the case
- 147 refers to the CTO
- -223 is the sequence for that location
- 2986 is the count (gross)
- FA denotes a fixed count average.

Raw field data will be transferred to the database for conversion to activity units (disintegrations per minute per 100 square centimeters [dpm/100 cm^2]), uncertainty calculations, and reporting.

4.3 STATISTICAL CONSIDERATIONS

In accordance with the MARSSIM (EPA 1997), distribution-free or nonparametric statistics will be used to demonstrate compliance with numerical goals for soil activity measurements. (A normal or log-normal distribution of data is not required to perform a statistical hypothesis test such as the t-test. The test requires that the samples be collected from randomly selected locations within the survey unit.) Appendix I contains additional discussion of background statistical considerations related to field counting. The following discussion relates to analysis of soil sample results only.

4.3.1 Null Hypothesis

Using the MARSSIM methodology, the Null hypothesis is stated as "the residual activity in the survey unit exceeds the release criteria" (EPA 1997). Thus, in order to pass the survey unit (that is, release the area), a higher standard must be met (more protective), by rejecting the null hypothesis. Under this hypothesis, the probability of making a Type 1 error is denoted by alpha (α), and a Type II error is denoted by beta (β). Alpha is set at 0.10, and beta is set a 0.10 for determining the initial number of samples to collect for the survey unit. The probabilities with which these conclusions are made may vary based on actual measurements and will be stated in the final report. The number of samples necessary may be determined by table lookup in the MARSSIM manual (EPA 1997). (The table is included in Appendix D.) The setting of alpha at 0.10 may be interpreted as a regulator's tolerance (of 10 percent) for an incorrect decision to release the site (using the prescribed statistical test) at the numerical goal. As the site concentration proportionately exceeds the numerical goal, the regulator's error probability will decrease, which would be illustrated on the retrospective power curve.

4.3.2 Statistical Test Performance

For comparison of survey units with 10 background reference area samples and from 12 to 50 survey unit samples, test operating characteristic (power curves) for alpha equals 0.01, have been constructed in accordance with the method described in the MARSSIM (EPA 1997) and are provided in Appendix D. These curves have been constructed in units of relative shift or (delta divided by sigma) (Δ/σ). These curves show the probability that a survey unit will pass the statistical test for the various sample sizes based on relative shift for a given chance that the survey unit will be incorrectly released (alpha) where observed sigma is in measurement units.

The units of the abscissa can be converted to measurement units (soil concentrations) from relative shift units as follows:

$$\textbf{measurement unit} = \{(\Delta/\sigma) \times (\textbf{observed } \sigma)\} + \textbf{soil concentration guideline}$$

for the power curve included in Appendix D, the observed pooled standard deviation (σ) is in measurement units.

For example, for a soil concentration guideline of 5 pCi/cm^3 and a pooled standard deviation of the dataset of 2.5 reading the power curve for a relative shift of 0.5 [(0.5 x 2.5) + 5 = 6.25] or an average concentration of the survey unit of 6.25, by reading from the abscissa (x or horizontal coordinate) to an vertical line intersecting any power curve (corresponding to n samples), the probability of the survey unit passing may be read from the ordinate. Note that with larger data sets, the probability of passing increases for a given relative shift.

From the regulatory perspective, sample size is not critical, because sufficient evidence to reject the null hypothesis (and pass the survey unit) requires more samples (for a given relative shift [Δ/σ]).

A sample data set of 30 site samples and 10 background samples was selected based on analysis of the power curve, an estimate of the pooled standard deviation for the background and site samples, and the need to sample within each excavation cell. The final number of samples may exceed 30 if more excavation samples are taken, or if ongoing data evaluation indicates more samples are required.

Examination of the MARSSIM sample size table for an alpha error (compliance or regulator's risk) of 10 percent at the numerical goal) and an expected pooled standard deviation of 1 picocurie per gram (pCi/g) shows that less than 40 samples is adequate.

4.3.3 Retrospective Confidence Levels

Due to the location of the soil beneath an active sewer pipe, the actual confidence level cannot be determined until after sampling is completed and results are analyzed. However, because the subsurface area is scanned with a sensitive radiation detector before sampling (having a scan minimum detectable concentration (MDC) below the numerical goal), prescanning prior to sampling, together with sampling, reduces to a minuscule degree the likelihood that a small area of elevated contamination is missed.

A retrospective power test will be performed based on the actual data obtained to demonstrate the actual operating characteristic curve for the survey unit. Sample test operating characteristics for a typical test are discussed in previous text (Section 4.3.2).

4.3.4 Demonstration of Compliance

For radionuclides present in background, conclusions will be drawn from survey results based on the MARSSIM guidance (EPA 1997) as set forth in the following table:

Survey Result	Conclusion
All results are less than 5 picocuries per gram (pCi/g)	Survey unit meets numerical goal
The difference between largest survey unit measurement and smallest reference area measurement is less than 5 pCi/g	Survey unit meets numerical goal
The difference between mean survey unit measurement and mean reference area measurement is greater than 5 pCi/g	Survey unit does not meet numerical goal
The difference between mean survey unit measurement and mean reference area measurement is less than 5 pCi/g The difference between any survey unit measurement and any reference area measurement is greater than 5 pCi/g	Survey unit and reference unit will be tested using the Wilcoxon Rank Sum Test and the Elevated Measurement Comparison Test (EPA 1997)

4.3.5 Quality Control Measurements

The laboratory statement of work contains laboratory control procedures required for this project (Appendix E). The following table identifies the field quality control measures for soil sampling.

Survey Unit	Quality Control Measure		
	MS/MSD[a]	**Duplicate Composite[b]**	**Random Independent Sample[c]**
Sewer Trench	1/10	1/10 or one per day	1/10 or 2
Radioactive Waste Disposal Shack	1/10	1/10	1/20 or 2 minimum
Backfill Soils	1/10	1/20 or one per day	1/10 or 2 minimum
Other Soils[d]	1/10	1/20	1/10 or 2 minimum

Notes:

a May be prepared from unused aliquot of soils collected on the same day.

b The field team will collect a second sample composite using the same procedure for selecting sampling locations and field composting.

c The field team will collect a single sample using judgmental sampling location from an area other than where the composite was collected.

d Includes background samples.

5.0 MEASUREMENT METHODS

The appended standard operating procedures (SOP) describe the methods used by the Navy CLEAN contractor to set-up, calibrate, and operate radiation detectors as well as record data and perform measurement quality control (Appendix A and D). Any deviations will be recorded on change forms and approved by the project health physicist. Identification of key project personnel responsible for measurements are identified in the quality assurance project plan (QAPP).

6.0 RADIOLOGICAL CHARACTERIZATION

Specific methods, instruments, and limitations of measurement systems are discussed in this section. The only contaminant assumed present is radium-226. The surface activity criterion for radium-226 is the lowest criteria for any radionuclide.

6.1 MEASUREMENTS OF GAMMA EXPOSURE RATE

Sites will be screened for low–level gamma radioactivity and determine gamma exposure rates using a gamma scintillation detector correlated to a pressurized ionization chamber or tissue-equivalent dose rate chamber calibrated for radium-226.

For exposure rate determinations used to document final site status, all measurements will be taken at 1 meter from the ground or floor surface either on grid nodes or at the highest location determined from a scan.

6.2 MEASUREMENTS OF GAMMA COUNT RATE

Gamma count rate responses will be used to determine whether specific areas exhibit activity levels that are significantly above site-specific background. Gross gamma count rates will be measured using a 2- by 2-inch sodium iodide (NaI) gamma scintillation detector system (Ludlum Instruments Model 2221 rate/scaler analyzer coupled to a Ludlum Instruments Model 44-10 or the equivalent). This radiation detection system measures energies in the range of about 80 to 3,000 kilo electron Volt (keV). This energy range includes gamma rays emitted by radium-226 and its decay products. The vendor will calibrate the instrument in a radium field, and the Navy contractor will source-check the response daily using ambient background radiation at a reference site. The scaler gamma energy threshold will be adjusted for an 80 keV threshold, and the window function will be disabled for screening measurements.

For site screening to detect low level gamma radioactivity sources, the detector probe will be moved along a grid line in a serpentine pattern while advancing at a speed of about 0.5 meter per second. The distance between the surface and the probe will be maintained at less than 5 cm. MARSSIM (EPA 1997) gives the sensitivity for such surveys as 2.5 pCi/g for radium-226 for small hot spots using the above survey parameters (2x2 NaI detection). This technique will be adequate to determine compliance with the numerical goal of 5 pCi/g. (A cylinder of radius 28 cm and depth 15 cm with 1.6 g/cubic centimeter (cm^3) density soil was used with radium-226 emissions for this example. A 95^{th} percentile error rate was used in the calculation.)

An area will be scanned to identify the highest activity location, then static measurements will be taken there and at other locations. The counting time for each measurement will be at least one minute; background measurements will be counted for at least 5 minutes. The distance between the surface being measured and the probe will be maintained at less than 5 cm.

6.3 DETERMINATION OF BACKGROUND

The procedure described in the following text can be used to establish background at a specified variance and confidence interval (NRC 1992). It is used when an instrument specific background must be subtracted, such as when using a scintillation detector.

Background should be determined so that variance is minimized and the measurement is made to a specified confidence interval. Background measurements are influenced by two major factors: counting error variations and locational/environmental variations of radioisotope concentrations for a single measurement. Counting error variations are controlled by accumulating sufficient counts or by using a rate measurement system that has a sufficiently long averaging time (slow response), such that the only appreciable source of intermeasurement variability is from sampling location variability.

Environmental variability is controlled by collecting sufficient point estimates of the natural background at multiple locations similar to the area of interest. To perform a background measurement to a variance of less than 20 percent at the n percent confidence interval, the following measurement process should be performed:

> Take 10 background measurements at various locations, accumulating enough counts to maintain counting error below 5 percent. Calculate the mean and standard deviation of the background and calculate the coefficient of variation:

$$2 \times S_b / X_b = \textbf{coefficient of variation (\%)}$$

If this value is greater than the coefficient of variation required, take additional measurements, calculated as follows:

$$((t_{n,\,df,} \times S_b) / (0.2_x\, X_b))^2$$

or for 10 initial measurements and a maximum variance of 20 percent:

$$84 \times (S_b / X_b)^2 = \textbf{number of additional samples}$$

where:

$t_{n,\,df}$	=	the t statistic for n-1 degrees of freedom
S_b	=	the standard deviation of the background measurements
X_b	=	the mean background determined by the initial measurements
n	=	the predetermined confidence interval, normally 95 percent

The Navy CLEAN contractor will use either survey grids established by the remediation contractor, where feasible, or space satellite-based positioning systems to establish outdoor survey grids and record scanning measurements. The system and operating procedure to be used for outdoor scanning is described in Appendix A.

6.4 DETECTORS FOR MEASUREMENT OF SURFACE ACTIVITY

Detectors for measurement of surface activity are described in the following text. Surface activity will be determined within Building 5 and Building 400.

6.4.1 Detectors Sensitive to Multiple Radiation Types

The thin-window pancake detector is an end-window detector (window perpendicular to the long-axis of the detector) in a pancake (window diameter is greater than detector depth) configuration. When using a window thin enough to admit alpha particles, a 10 to 20 percent detection efficiency is achieved. This detector is operated as a Geiger Müeller (GM) counter so that interactions of alpha particles, beta particles, or gamma photons within the detector are indistinguishable. The pancake GM detector may be used for spot measurements, and in areas where use of larger detectors is physically constrained by geometry.

Large area gas detectors (or phoswich[3] dual alpha beta detectors) will be used in place of the GM detectors for scans. A shielded GM tube will be used for field counting swipes for beta activity. Actual detector efficiencies will be determined by the survey team during calibration. The configuration of detectors that are commercially available may have backings that are unshielded, lead shielded, or tungsten shielded. The shielding reduces background noise and thus increases sensitivity. Initially, an unshielded detector will be used. Selection of detectors will be made with due consideration for energy, efficiency, and geometry factors.

6.4.2 Measurements of Beta-Gamma Activity

The Navy CLEAN contractor will measure beta-gamma activity by using a pancake-style GM beta-gamma detection system for small areas and a gas flow proportional counter (or phoswich) for large floor areas. The detection sensitivity of the pancake type of detection system is (1) about 2,000 to 3,000 dpm/100 cm^2 for scanning measurements and (2) less than 500 dpm/100 cm^2 for static 1-minute counts. Sensitivity for this measurement can be enhanced by increasing the counting duration or using a larger area detector. (For large area detectors greater than 300 cm^2, the field action limit is proportionally reduced so that areas with surface activity above the maximum allowable limits are not inadvertently averaged by the detector.) Counting times will be field adjusted as necessary to meet detection limit requirements

For the purpose of these measurements, the beta-gamma activity expressed in disintegrations per minute per 100 cm^2 is calculated by the equations given in Appendix A.

For beta radiation, which has limited ranges in air, the distance between the detector probe and the surface being measured will be maintained at less than 2 cm. The required scan speed will be calculated in accordance with the MARSSIM. Calculations of scanning detection limit will be included in the final report.

3 A phoswich detector contains one alpha-sensitive layer and one beta-sensitive layer; therefore, alpha and beta emissions may be counted simultaneously.

6.4.3 Detectors Sensitive to Alpha Radiation

The thin-window alpha detector is a large area (50 to 100 cm^2) mylar window protected with zinc sulfide or plastic and coupled to a photomultiplier tube. The detector is sensitive only to alpha radiation, so it may be used to assess alpha emitting contaminants in a mixed beta-gamma emitting environment.

6.4.4 Measurements of Alpha Activity

The Navy CLEAN contractor will measure alpha activity on the interior surfaces of the rooms and equipment and fixtures in the rooms. A zinc sulfide alpha scintillation probe (Ludlum Instruments Model 43-65, or the equivalent) coupled to a rate/scaler single channel analyzer (Ludlum Model 2221, or the equivalent) will be used for these measurements. The detection sensitivity for this type of detector system is approximately (1) 300 dpm/100 cm^2 for scanning measurements and (2) 50 dpm/100 cm^2 for static 1 minute counts. Sensitivities for scanning are as presented in the MARSSIM. Sensitivity for the alpha measurement can be enhanced by increasing the counting duration. Counting times for fixed counts will be field adjusted as necessary to meet detection limit requirements.

For alpha particle emissions, which have very limited ranges, the distance between the zinc sulfide alpha scintillation probe and the surface being measured will be maintained at less than 1 cm. The scan speed will not exceed one-half of the probe width per second.

6.4.5 Evaluation of Radium by Beta Activity

Compliance with surface activity limits may be demonstrated by assessing either alpha radiation or beta radiation or both (EPA 1997). (The surface limit for a nuclide is an activity limit, not an emission rate limit; therefore, the activity may be inferred by a surrogate radionuclide where the relationship between two nuclides is known.) Reliance on alpha measurements may be problematic because of highly variable degree of alpha attenuation caused by rough, porous, or dusty surfaces (EPA 1997). Measurement of beta activity, where a known relationship between the alpha and beta emissions from the decay chain exists, may produce a more reliable estimate of surface activity. (The condition of secular equilibrium between radium and its progeny can exist because the transformation rates [decay constant] of all progeny are much higher than for radium.) At 50 percent of equilibrium[4] (a correction is necessary to account for possible leakage of radon-222 as a gas), approximately 1.4 beta particles of sufficient energy

4 This is considered a suitably conservative assumption.

are released per radium-226 alpha particle (see table below); therefore, the derived value for beta activity as a surrogate (based on NRC Regulatory Guide 1.86) is 140 dpm/100 cm^2 (average) and 420 dpm/100 cm^2 (maximum) beta activity. This can be achieved (in accordance with the MARSSIM methodology) using a 100 cm^2 probe at a scan speed of approximately 8 cm/second (120 seconds per m^2 surveyed). With a 100 cm^2 gas proportional detector, a limit of detection (L_D) of approximately 100 dpm/100 cm^2 is achievable with less than 1-minute fixed counts; therefore, beta counting may be useful to check rough surfaces, painted surfaces, or other surfaces, not suitable for alpha counting. If beta activity is identified, an alpha measurement will also be made as a check on the assumption of equilibrium.

MAJOR RADIATION ENERGIES (MeV) AND ABUNDANCE FOR RADIUM-226 CHAIN BETA EMISSIONS

Nuclide	Energy (MeV)	Abundance (%)	Nuclide Total (%)
Lead-214	0.67	48	NA
Lead-214	0.73	42.5	NA
Lead-214	1.03	6	96%
Bismuth-214	1.42	8.3	NA
Bismuth-214	1.5	17.6	NA
Bismuth-214	1.5	17.9	NA
Bismuth-214	3.27	17.7	61.5%
Lead-210	.063	20	20%

MAJOR RADIATION ENERGIES (MeV) AND ABUNDANCE FOR RADIUM-226 CHAIN BETA EMISSIONS

Nuclide	Energy (MeV)	Abundance (%)	Nuclide Total (%)
Bismuth-210	1.16	100	100%
Total (secular equilibrium)	--	--	277.7%
Total (50 % equilibrium)	--	--	144%

Notes:

MeV million electron volts

NA not applicable

-- no total applicable

6.5 CALIBRATION

Detectors are calibrated by the survey team to National Instrument Standard Technology (NIST) traceable sources in accordance with the attached procedures, and by the instrument supplier (or other calibration facility) on an annual basis.

6.6 CHARACTERIZATION OF SOIL CONTAMINATION

Methods for sampling and analysis of soils to demonstrate compliance with numerical goals are described in the following text. Sampling is supplemented with scanning measurements.

6.6.1 Survey Units

Survey units requiring soil sampling are identified in the following table.

SOIL SAMPLING REQUIREMENTS

Survey Unit	Sample Frequency	Surface Scan
Sewer Trench	Two-point composite from two evenly spaced sampling locations will be collected per 100 linear feet of trench	yes
Radioactive Waste Disposal Shack	One per 10 m^2	yes
Backfill Soils	One sample per 10 cubic yards, field screened and field composited into one analytical sample per 100 cubic yards of fill	no
Other Soils	To be determined	

6.6.2 Direct Surveys

The Navy contractor will perform direct surveys of uncovered excavations to identify elevated areas and locate soil samples using a gamma scintillation detector. The detector probe will be moved along a grid line in a serpentine pattern while advancing at a speed of about 0.5 meter per second. The distance between the surface and the probe will be maintained at less than 5 cm. Gamma count rate responses will be used to determine whether specific areas exhibit activity levels that are significantly above site-specific background.

The Navy contractor will scan an area to identify the highest location, then take static measurements there and at other locations.

6.6.3 Soil Sampling

Soil samples will be collected of undisturbed soil at the borders of excavation, soil for reuse as backfill, surface soils at the radioactive waste storage shack area, and any other necessary areas to be determined during the course of the project.

Surface soils will be collected such that a depth profile of 0 to 15 cm is maintained. Rocks and large organic material (roots and twigs) will be removed. Surface soil samples will consist of a composite collected from 100 cm^2 by 15 cm deep. The corners and center of four 1-meter grid areas will be field mixed, and a 2-liter soil volume sample will be prepared for laboratory analysis. One of 10 samples will be field duplicated for counting. Samples will be collected from random nodes on a uniform grid.

Soils to be used as backfill will be sampled at the rate of one 2 gallon sample per 10 cubic yards, field screened, and field composited into one 2 liter analytical sample per 100 cubic yards of fill. Sampling will be conducted by trowel, scoop, or driven tube sampler if the material is in piles greater than 2 feet deep.

The sewer excavation consists of one survey unit. The total number of samples will be derived using the MARSSIM methodology for a contaminant also present in background (EPA 1997). A minimum of 36 samples from the site and 10 background samples will be collected in order to achieve the necessary statistical power. Soils within the limits of the excavation will be selected for sampling after a gamma radiation scan of the surface soil identifies the area of highest detector response. Soils will be sampled from an excavator bucket or with a tube sampler. If the gamma scan shows relatively uniform response, one sample consisting of a composite from four evenly spaced sample locations will be collected per 100 linear feet of trench. If the variation between highest and lowest detector response is greater than a factor of 3, one sample will be collected at the highest location, and the second sample composited from four evenly spaced locations per hundred feet of trench.

Additional soil samples may be collected and field screened using the scintillation detector connected to a ratemeter/scaler, single channel analyzer, or field-based spectrometer. The activity of field screened samples will be estimated by correlation to laboratory analyzed samples. Field screened data will be used to support the conclusions obtained by laboratory measurement and to provide better assurance that the numerical goals have been attained.

The off-site verification laboratory will quantify radium-226 by measuring the 186.4 KeV photon emissions. After analysis, the laboratory will correct all results to a dry-weight basis.

6.6.4 Characterization Measurements of Drain Line Contamination

To characterize the extent of radium-226 contamination in the remaining sewer pipes of Buildings 5 and 400 as well as in the pipes leading to the seaplane lagoon, the Navy remediation contractor will perform surveys or sampling within the interior of drain lines and pipes in accordance with the RRATSs for this task (TtEMI 1998a). Navy CLEAN contractor personnel will witness the detector calibration, sampling or data obtained from additional surveys. The remediation contractor will use a gamma scintillation detector to characterize radioactive contamination resulting from the presence of radium-226 in the drain lines. The technology applied will be capable of surveying lengths of pipe of up to 250 feet with diameters as small as 2 inches.

The sensitivity achieved by these final tests will be unchanged from that achieved by the original characterization survey; that is it will range from less than 4 to less than approximately 15 nanocuries, as a point source equivalent, depending on the detector size, counting geometry, and other factors.

Within the buildings, as intersecting or crossing lateral pipelines that were not identified in the technical work document are uncovered, they will be evaluated. As appropriate, based on external radiation surveys, and identification of the line, crossing laterals may be opened for radiation surveys.

6.7 GROUNDWATER SAMPLING

Groundwater and water from the seaplane lagoon will accumulate in the trench during the excavation activities. This water will be collected by pumping the trenches dry as necessary for construction and confirmation sampling. Water from this activity will be collected in temporary storage tanks located on site. The Navy CLEAN contractor will witness the circulation (in order to assure a representative sample) and sampling of these tanks. The Navy CLEAN contractor will collect quality assurance samples in accordance with its standard operating procedure (SOP No. 010, Revision No. 3, Groundwater Sampling) and the project QAPP. Samples will be analyzed for metals (EPA 6010B), purgeable aromatic compounds (EPA 8020) , purgeable halocarbons (EPA 8010) volatile organic compounds (EPA 624), semivolatile organic compounds (EPA 625), total petroleum hydrocarbons (EPA 8015), total polynuclear aromatic hydrocarbons (EPA 610), radioactivity (EPA 901.1) (radium-226 only), hydrogen ion concentration (pH test paper), and ethylene dibromide (EPA 504) (once only).

The Navy CLEAN contractor will verify that for each batch discharge to the seaplane lagoon, the water meets the regulatory limit established for the project. The proposed limits for discharge to the seaplane lagoon or land application are provided in the following table. Following verification, the Navy CLEAN contractor will notify the Navy on site representative that the water may be discharged as authorized by the Final Technical Work Document/Removal Action Plan for Removal of Radiation Sources at Alameda Point and Final Removal Site Evaluation. Discharge for land application will be tested with the first batch and every third batch thereafter.

The Navy will use a laboratory certified for drinking water analysis by the State of California for radiological analysis of water collected from the excavation. The laboratory will use EPA-approved or equivalent methods, which may include gross alpha analysis, radon emanation techniques, or gamma spectroscopy for analysis of water. The detection limit or minimum detectable concentration for any method used will be less than 60 pCi per liter of water.

Water not meeting these limits will be treated on site and retested or disposed of off site.

6.8 MINIMUM DETECTABLE ACTIVITY

Minimum detectable activity (MDA) is a measure of the smallest quantity of activity that could be present and not be detected and is specific to each detection system. The MDA of a detection system is a function of the counting time, background count rate, detector efficiency, and the surface area of the detector probe.

The Navy CLEAN contractor will calculate MDA for activity measurements for each detection system by using the equations provided in the attached low-level radioactivity counting procedure (Appendix A) for fixed counting and as discussed in Appendix I and the MARSSIM (section 6.7.2.1 for beta-gamma emitters and 6.7.2.2 for alpha emitters) for beta-gamma and alpha scanning.

The interrelationship between the scan MDA and the grid spacing is described in NUREG-1507 (NRC 1998). For radium-226, at the surface activity limit, external gamma dose is an insignificant consideration, therefore it was assumed that the dose is proportional to the total residual activity present on surfaces (NRC 1988). Examination of Table 8.2 and Figure 8.3 of NUREG-1507 revealed that an area factor relationship:

$F_{area} = {}^{36}\!/\,A_{MDC}$ could be substituted into the relationships of section 3.8.2 (NRC 1998). The resulting function for the grid spacing, L, (applicable to square grids, indoors, for radium-226 only) is plotted below. This relation shows that a grid spacing of 2 meters is sufficient, provided the scan MDA is less than 9 times (900 dpm/100 cm^2 alpha activity) the surface activity limit (or DCGL in MARSSIM terminology). A grid spacing of 2 meters will also provide more than enough measurements to perform the sign test on these measurements.

SURFACE WATER EFFLUENT DISCHARGE LIMITATIONS FOR EXTRACTED GROUNDWATER AT ALAMEDA POINT

Constituent	Maximum Limit (µg/l)	Method[1]
Purgeable Halocarbons		
1,1,1-Trichloroethane	5.0	EPA 601
Tetrachloroethylene	5.0	EPA 601
Trichloroethylene	5.0	EPA 8010
1,1-Dichloroethylene	5.0	EPA 8010
1,2-Dichloroethane	0.5	EPA 8010
Vinyl Chloride	0.5	EPA 8010
1,2-Dichloroethylene isomers	5.0	EPA 8010
1,1-Dichloroethane	5.0	EPA 8010
1,1,2-Trichloroethane	5.0	EPA 8010
Methylene chloride	5.0	EPA 8010
Chloroform	5.0	EPA 8010
Purgeable Aromatics		
Benzene	1.0	EPA 8020
Toluene	5.0	EPA 8020
Ethylbenzene	5.0	EPA 8020
Total xylenes	5.0	EPA 8020
Other Organics		
Total petroleum hydrocarbons-purgeable and extractables	50.0	EPA 8015
Ethylene Dibromide[2]	0.02	EPA 8260
Total polynuclear aromatic hydrocarbons	15.0	EPA 8270
Semivolatile Organic Compounds (Base/Neutral Fraction) per constituent	5.0	EPA 8270

SURFACE WATER EFFLUENT DISCHARGE LIMITATIONS FOR EXTRACTED GROUNDWATER AT ALAMEDA POINT (Continued)

Constituent	Maximum Limit (µg/l)	Method[1]
Inorganics		
Arsenic	20.0	EPA 6010B
Cadmium	4.4[3]	EPA 6010B
Chromium (VI)	44.0	EPA 6010B
Copper	47.2[3]	EPA 6010B
Lead	12.8[3]	EPA 6010B
Nickel	640.0[3]	EPA 6010B
Selenium	20.0	EPA 6010B
Silver	16.4[3]	EPA 6010B
Zinc	440.0[3]	EPA 6010B
Radioactivity		
Radium-226	60 picocuries/liter[4]	EPA 901.1[5]

Notes:

1 All methods are "or equivalent"

2 first sample batch only will be tested

3 assumes hardness = 100 mg/l $CaCO_3$

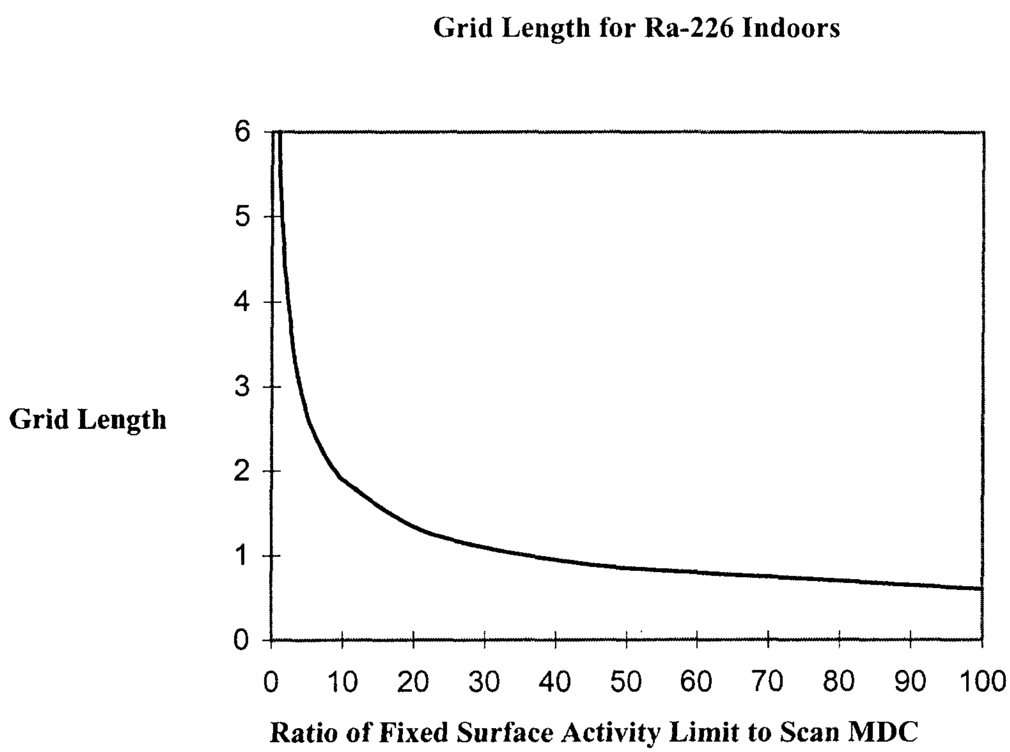
4 water in excess of 60 picocuries per liter Ra 226 will not be applied to land.

5 The laboratory may use alternate methods to quantify this parameter.

The pH of the effluent shall not exceed 8.5 nor be less than 6.5.

Source: Order No. 94-087 (NPDES No. CAG912003) April 23, 1998, California Regional Water Quality Control Board, San Francisco Bay Region

Illustration Of The Relationship Between Scan MDA And Activity Limit To The Required Grid Spacing For Fixed Counts For Radium-226 Indoors



7.0 SPECIFIC SURVEY TASKS

The radiological survey has been divided into the following tasks:

- Establish site-specific radiation background levels for soils by sampling and laboratory analysis
- Survey specified areas of IR Site 2 (radioactive waste storage shack) after remediation
- Survey specified drain lines of Buildings 5 and 400 and associated storm sewer lines upon exposure by the remediation contractor
- Survey specified areas of Buildings 5 and 400 for residual surface activity
- Test water for radioactivity, metals, and organic compounds; compare to established project limits prior to discharge
- Survey Seaplane Lagoon sediments near the outfall at project completion

The following sections describe how each of these tasks will be performed.

7.1 SITE-SPECIFIC RADIATION BACKGROUND LEVELS FOR SOILS

Ten or more soil samples will be collected for the sewer survey unit from soils of a similar geological type at locations believed to be unaffected by the industrial disposal activity. At the same locations, detector responses will be established and correlated to exposure rate. These soils samples will be analyzed by gamma spectroscopy and by alpha spectroscopy for isotopic uranium. (Comparison of the Uranium-235/Uranium-238 (U-235/U-238) ratio and U-238 concentrations to the Ra-226 concentration will help to determine if the sample is representative of background conditions).

7.2 SITE 2 (RADIOACTIVE WASTE STORAGE SHACK)

The Navy CLEAN contractor will conduct the walkover survey for low level gamma activity by using a scintillation detector. If a count rate is determined to be significantly above background levels, the location will be marked, and surface samples will be collected from the site. Up to six additional surface samples may be collected for laboratory analysis. The sample locations will be determined based on the instrument survey.

7.3 DRAIN LINES OF BUILDINGS 5 AND 400 AND ASSOCIATED STORM SEWER LINES

The Navy remediation contractor will use methods, procedures, and specifications as described in its work plan, to characterize radioactive contamination resulting from the presence of radium-226 in the remaining building drain lines and storm sewer lines at the limits of the excavation. The specified drain lines and sewer lines will be surveyed by the remediation contractor when exposed by the excavation upon exposure. The Navy CLEAN contractor will witness these measurements.

7.3.1 Building 5 Drain Lines and Storm Sewer Line F

The affected drain line in Building 5 and the affected section of storm sewer line F are described below.

7.3.2 Building 5 Drain Line

Radiological Removal Action Drawings (TtEMI 1998b) sheet 3 illustrate utilities within, and in the vicinity of Building 5.

The affected drain line inside of Building 5 starts above the Small Parts Paint Shop on the east side of the room, runs along the ceiling, and travels down the north wall, where it enters the concrete floor. The remainder of the building drain line consists of over 500 feet of subterranean piping.

Where the drain line enters the concrete floor in the Small Parts Paint Shop, the pipe is 4 inches in diameter. The drain line travels north in Building 5 for 60 feet under the fire lane into Building 5A, where it turns 90 degrees to the west. At this point, the drain line is shown to be 10 inches in diameter. The drain line travels west under the concrete floor for approximately 460 feet, where it leaves the footprint of the building. Along this 460-foot section, access to the drain line is possible through four clean-outs. At this point, the diameter of the line has increased three times to a diameter of 18 inches. The line changes diameter again outside of the building footprint to 21 inches. The drain line travels another 100 feet outside of the building, where it connects to the first storm sewer manhole, 6F-2, of storm sewer line F.

7.3.3 Storm Sewer Line F

Storm sewer line F starts at the point outside of Building 5 where the Building 5 drain line connects to manhole 6F-2, as shown on Radiological Removal Action Drawings, sheet 3 (TtEMI 1998b). From this point, storm sewer line F travels west for 150 feet, then turns south for approximately 1,850 feet, where it ends at the Seaplane Lagoon. The reach of Storm Sewer Line F from outside Building 5 to the Seaplane Lagoon is shown on sheet 4 of the Radiological Removal Action Drawings (TtEMI 1998b). At the point where the storm sewer line leaves the footprint of Building 5, it is 21 inches in diameter. At the outfall in the Seaplane Lagoon, the pipe is 36 inches in diameter. Throughout the 1,850-foot north/south section of storm sewer line F, six east/west lateral sections of storm sewer line connect at or near manholes 1F through 6F. These lateral sections service areas of the base along the south wall of Building 5, the north and south walls of Building 400, and around Buildings 19, 23, 24, and 25 for a total of approximately 7,700 feet.

7.4 BUILDINGS 5 AND 400

The following areas are known or suspected to contain radioactive contamination: (1) the Bearing Shop in Building 5, (2) the Small Parts Paint Shop in Building 5, and (3) Rooms 203, 204, 210, 213, and 214 of Building 400. These areas will be surveyed for the presence of radium-226 and its decay products. The survey areas for Buildings 5 and 400 are about 5,000 and 4,000 square feet, respectively. As the previous Building 5 surveys were characterization surveys and were not intended for use in the final release of the building, these rooms will be resurveyed. The Building 400 surveys previously conducted were designed as final status surveys to allow unrestricted release of the affected areas; therefore, only areas previously identified as elevated areas will require resurvey.

The Building 5 survey will provide 100 percent coverage of the floor and up to 2 meters height on the walls of the Bearing Shop. The survey of the floors and walls in the adjacent rooms and hallway will use a systematic grid survey method to provide at least 10 percent coverage of the surface areas.

The Building 400 surveys will provide 100 percent coverage of the bare floors and up to 2 meters in height on the walls. Exposed drainage pipes and fixtures not removed from the rooms will also be surveyed.

Before starting survey activities, the Navy CLEAN contractor will establish a 1-meter grid system over the floor and wall surfaces of the survey areas.

Clean smooth surfaces will be scanned with an alpha sensitive or beta sensitive detector. Rough surfaces will be scanned with a beta sensitive detector . The health physicist will evaluate problems with alpha sensitivity and may increase the proportion of surfaces receiving both alpha and beta activity measurements. if either type are demonstrated to be problematic or ineffective.

For optimum detection sensitivity, changes in the instrument response will be monitored by visual and audible outputs. Locations of direct radiation, discernible above the ambient background level, will be noted in the field logbook, marked, and mapped.

Removable contamination measurements will be made by taking surface swipes at locations of elevated total alpha activity and in areas that are likely to have trapped or pooled contaminated liquids, such as cracks and floor-wall joints. Swipes for assessment of removable surface activity will be obtained by using a dry filter paper, such as Whatman 50 or equivalent, to wipe an area of approximately 100 cm^2 while applying moderate pressure. A 3-cm-diameter filter is typically used; however, for surveys of small penetrations, such as cracks or anchor bolt holes, cotton swabs will be used to wipe the area of concern. The swipes will be placed in sample containers, which will be surveyed using the zinc sulfide alpha scintillation detector to determine removable alpha contamination levels.

When reporting survey results, levels of radioactivity will be reported to be "above background" if the value (in counts per minute) is greater than the critical level (L_C), and assigned an uncertainty estimate if the value (in counts per minute) is greater than the L_D. The L_C is the level at which there is a 5 percent chance of calling a background sample value "greater than background" (that is, the probability of a false positive is 5 percent). This value will be used when counting samples or making direct radiation measurements. Any response above the L_C will be considered above background (or a net positive result). The L_D is the level at which the smallest amount of radioactivity will statistically yield a net result above method background. (For a detection system, the L_D is equal to the MDA when the units are converted from counts per minute to disintegrations per minute per 100 cm^2.). A 95 percent confidence interval will also be calculated for all responses greater than L_D. For a detailed explanation of how L_C, L_D, and MDA limits are determined, see Appendix A and MARSSIM (EPA 1997).

7.5 WATER TESTING

One water sample will be collected per planned discharge event prior to the discharge. The sample will be a volume weighed composite from all tanks composing the discharge. Tanks will be circulated and well-mixed prior to sampling. Analytical results will be compared to the limits in Section 6.7. Water will be tested and retested as necessary to meet discharge limits.

7.6 SEAPLANE LAGOON SEDIMENTS

At the completion of the construction, six samples will be collected from the vicinity of the "F" line outfall. These samples will be collected from surface sediments as grab samples at the lowest monthly tide within the 30-day period following construction completion. Samples will be analyzed for radium-226, and analytical results will be reported as dry weight.

8.0 DATA EVALUATION AND PREPARATION OF RECOMMENDATIONS

The data collected from these surveys will be reviewed to determine whether any of the elevated radiation levels or contamination levels exceed numerical goals. The following table summarizes the types of measurements that will be collected for each respective survey to be evaluated:

	Volume Activity		Surface Activity		
Location	**Gamma Exposure Rate**	**Soil Activity**	**Removable Radium-226 Activity**	**Total Radium-226 Activity**	**Total beta-Gamma Activity**
Radiation waste storage shack, Site 2	X	X	--	--	--
Building 5 drain line route	X	--	--	X	--
Building 400 drain line route	X	--	--	X	--
Room surfaces, Building 400	--	--	X	X	X
Room surfaces, Building 5	--	--	X	X	X
Storm sewer route	X	X	--	--	--
Storm sewer manholes and remaining lines	X	--	--	--	--

Based on contamination and/or gamma exposure levels, the Navy CLEAN contractor and RASO personnel will make recommendations for unrestricted release.

The survey data will be compiled in a formal report, which is discussed in Section 10.0 Data will be accompanied by text describing the surveys and explaining the results in detail. Survey data necessary for the report will include, but not be limited, to the following:

- Anomalous locations
- Gamma count rates
- Gamma exposure rates at 1 meter
- Beta surface activities
- Alpha surface activities
- Removable alpha surface activities
- Detection limits

All conclusions and recommendations reported will be supported. The document will include maps, survey grids, data tables, summary figures, and necessary equations and calculations.

9.0 QUALITY ASSURANCE

The QAPP addendum identifies the project-specific components as an amendment to the "Characterization of Seaplane Lagoon, Quality Assurance Project Plan" (PRC 1996b) and the CLEAN II quality control management plan (QCMP) (PRC 1995).

10.0 SURVEY REPORT

A radiation close out survey report (RCS) will be prepared to formally document activities performed under this work plan. The report will include the following sections:

- A summary of the survey, types of testing performed, quantities of measurements by type, significant results, problems and their resolutions, and data validation
- A facility description including sketches or facility drawings that indicate the survey grid, special sampling locations, and locations of areas with high potential for retaining residual activity
- A description of the instruments actually used to complete the RCS, including detection limit calculations, summary of quality control, and a summary of any significant problems related to the instruments
- A description of the survey results, including a discussion of all anomalies, independent survey results, and laboratory analytical results
- A discussion of the results of data validation activities

- A summary of procedural and work plan variations, if any
- Conclusions and recommendations

In addition to the report sections listed previously, the following appendices will be provided in the RCS report:

- Facility photographs, drawings, and diagrams
- Instrument data sheets
- Daily report
- Source certificates
- Instrument calibration records
- Quality control records
- Survey and scan data
- Swipe count results
- Detection limit calculations
- Data validation calculations
- Identification of areas exceeding criteria
- Surveyor identification and handwriting sample
- Condition of drain lines excavated, estimated activity (if not previously provided), and depth of excavation

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APPENDIX A

STANDARD OPERATING PROCEDURES

Low Level Radioactivity Counting Procedure

Exposure Rate Surveys At 1 Meter In Outdoor Areas Using Global Positioning System

Source Handling Requirements for Licensed Sources

Field Instrument Calibration and Operational Checks

BACKGROUND

This standard operating procedure (SOP) provides a standard approach for implementing Tetra Tech EM Inc. (TtEMI) radiological clearance surveys at Comprehensive Long-Term Environmental Action Navy (CLEAN) contract project field sites.

PURPOSE

This procedure provides a method for performance of final clearance surveys and describes the instrument selection, use, calibration and methods for radiological clearance surveys.

SCOPE

This SOP applies to all Navy sites that involve final radioactive contamination clearance surveys under the CLEAN contract projects. TtEMI uses a standard database programmed in Microsoft Access™ to manage data from large projects. Some data recording techniques refer to terms and data fields used by that database system. Attachment 1 contains some of the terms used. Contact the project health physicist for more information concerning use of the database..

DEFINITIONS

Critical Level (L_C)	The term used to define the *a posteriori* sensitivity of a measurement.
Cursory Survey	A radiation survey performed with or without traceable or formally calibrated instruments, detailed documentation, or appropriate data quality to support final status survey requirements. Cursory surveys do not have associated quality control measurements, formal reports or detailed documentation; however, instruments must be set-up, checked, and operated in accordance with this procedure for measurements to be valid.

Detection Level (L_D)	The term used to define the *a priori* sensitivity of a measurement.
Remedial Action Support Survey	Survey conducted in real-time mode while remediation is underway to guide remediation and determine when site is ready for final survey.
Final Status Survey	Survey conducted independent of the remediation action to demonstrate the survey unit is below the release criterion or numerical goal[1] established for the project. Data from remedial action support surveys may be used to support final status survey decision provided that data quality is appropriate.

REQUIREMENTS AND RESOURCES

The following are necessary before proceeding with this procedure.

The user must be trained and qualified in the subject matter. This SOP does not contain sufficient detail for the user who lacks special training and experience in health physics.

- Alpha- and beta-emitting calibration sources with appropriate source certificates
- Radiation detectors, connecting cables, and rate meter scalers
- Calibration and data recording forms
- Counter gas (P-10), regulator, and flow meter
- Contamination swipes
- Sample holders
- Project work plan
- Calculator

1 Numerical goals may be health based in accordance with CERCLA or based on action specific requirements. Numerical goals may also be derived to meet a dose based (e.g. 15 millirem) or risk based criteria.

REFERENCES

General references are attached (Attachment 2).

PROCEDURE

This section discusses responsibilities, instrument selection, instrument use, calibration, data recording, and data quality assurance measures.

INSTRUMENT DESCRIPTIONS

This subsection describes the types of instrument detectors used for final clearance surveys. Detectors are classified as sensitive for radionuclides that (1) decay by alpha emission and (2) decay by beta emission. Several detectors are available for each type of radiation, depending upon the desired characteristics, such as ruggedness, speed, sensitivity, and selectivity. Table 1 summarizes the detectors readily available and their salient operating characteristics for clearance radiation surveys.

Detectors Sensitive to Alpha Radiation

Detectors sensitive to alpha radiation include the end window Geiger-Müeller (GM) detector, the gas-proportional detector (GP), and the alpha sensitive scintillation detector (AS).

Detectors Sensitive to Beta Radiation

Detectors sensitive to beta radiation include the thin window GM and the GP.

Detectors Sensitive to Both Radiation Types

The thin window GM is sensitive to both alpha and beta radiation. The GP may be operated in alpha only detection mode or alpha plus beta detection mode by choice of operating parameters. The GP may be used to monitor beta radiation only in a mixed field from the difference or by using an additional shield over the window.

INSTRUMENT SELECTION

The following subsections discuss some factors to be considered during instrument selection. The work plan should include a description of the specific instruments to be used for each survey.

Area to be Surveyed

If large areas are to be surveyed, the large GP probe is the best choice for beta activity. For small areas, or objects with complex shapes, small probes are best. The end window or pancake GM may be best for access to small areas.

Radioactive Contaminants of Potential Concern

Contaminants may be known, such as, in the case of a radium paint shop, mixed, such as at a research facility, or unknown, where detailed operating records are not available. The contaminants known or suspected will influence the detector and methods of survey. Choice of detector, calibration standard, and required detection limits should be reviewed with a health physicist before proceeding with the survey.

Known Contaminants

If the contaminant is known, apply the release criteria established for the contaminant.

Unknown Contaminants

If the contaminants are not known, the most restrictive release criteria will apply (that is, assume alpha-emitting contamination is radium-226 and beta-gamma-emitting contamination is strontium-90 in selecting release limits. For release limits, use the values set forth in Table 2, "Surface Radioactivity Limits For Release of Materials" or numerical goals derived specifically for the project.

CALIBRATION SOURCES

Standard calibration sources are available for precise detector calibration with traceability to the National Institute of Standards and Technology (NIST). Sources are available in different physical forms to account for the effects of both backscatter and self absorption. Sources are U.S. Navy property and are available to any CLEAN project. In addition to standards, several transfer standards are available which may be used to maintain field response checks. Contact the health physicist for information on the characteristics of each radionuclide standard available from the CLEAN program. Additional sources without traceability are also available. The radiation sources are discussed in the following subsections.

Alpha Activity

Thorium-230 provides a stable alpha-emitting source or moderate energy for use in calibrating alpha-sensitive detectors. The daughter product (radium-226) will not ingrow sufficiently to effect the standard. A plated standard and solution standard deposited on filter paper are available. The surface emission rate should be used for the activity content of the filter paper standard, and the total contained activity for the plated standards.

Beta Activity

Several beta-emitting standards are available and should be matched to the isotope of concern. Tecnititium-99 is a low-energy beta emitter that can be used to calibrate for isotopes having e_{max} less than 0.5 MeV. Chlorine-36 is a moderate-energy beta emitter that can be used to calibrate for isotopes having e_{max} energies from 0.4 to 1.5 MeV. Both Tecnititium-99 and Chlorine-36 are pure beta emitters (no associated gamma photons are emitted) with long half-lives.

COUNTING PRECISION

Count precision is measured by the coefficient of variation. To count to a predetermined level of precision (95th percentile confidence interval), referring to Table 3, look up the required precision in the last column, and collect the number of counts specified in the second column.

BACKSCATTER CORRECTION

A backscatter correction may be applied. This correction is used to account for the effect of differences between the stainless steel source and the surface being monitored, usually wood or concrete. This correction is only applied to direct contamination measurements. A filter paper beta source standard eliminates the need to correct for backscatter. When correcting from a high atomic number material (steel) to a lower atomic number material, the effect is to reduce the activity measured; therefore, not applying the correction is conservative. The correction ranges from 10 to 20 percent. The correction is only made for direct beta measurements and is only necessary if the result would be materially affected. Any backscatter correction applied shall be indicated in the final report.

INSTRUMENT SETUP

The following sections describe the setup for the rate meter/scaler and each detector. Each detector and rate meter scaler shall be checked against standards or transfer sources before use. Rate meter/scaler setup is discussed first, followed by detector setup.

Rate Meter/Scaler Setup

The rate meter/scaler must first be set up and inspected as discussed in the following subsections.

General Parameters

The following parameters must be adjusted before the rate meter/scaler can be used: (1) high voltage, (2) threshold, (3) window, (4) response, (5) operation mode, and (6) range. The following descriptions are for the Ludlum series of instruments, but other manufacturers have similar settings.

Visual Inspection

The instrument should also be visually inspected for the following: (1) battery condition and voltage (the battery check should indicate at least 6 volts), (2) cable free from damage or nicks, (3) case and instrument face not damaged, (4) cable not producing spurious noise, and (4) detector not sensitive to visible light. Setup is discussed in the sections that follow.

Counter Chi Square (χ^2)

This test demonstrates reliability of the scaler and should be conduced at the start of the project and monthly thereafter. To test chi square, take 20 to 30 repeat count measurements for the intended count time (normally 1 to 5 minutes) with a high activity (greater than 1,000 counts per minute [cpm]) source under identical conditions and calculate the statistic given here from the observed (O) and expected (E) counts.

$$\chi^2_{(df)} = \Sigma \ (O - E)^2 / E$$

Compare the statistic to the limits for n-1 degrees of freedom (0.5) given in the statistical tables (Attachment 5). Failure to pass (χ^2 greater than table value) this test may be an indication of scaler instability. Repeat the test if the counter fails and consider replacement if the counter fails more than two times.

Voltage Plateau

A proper operating voltage must be selected for each detector in accordance with the detector operating physical principles and manufacturers recommendations. The operation point is selected at a point approximately one-third to one-half of the width greater than the "knee" when the operating plateau is plotted as response versus voltage. The detector plateau is normally determined once per project or monthly for each detector and plotted on a detector setup form. The plateau is plotted in 25-volt (V) to 50-V increments. Normal operating voltages for each detector are described in Table 4.

Geiger Müller Detector

The correct operating voltage is between 600 V and 900 V. The GM detector cannot be used in single channel or "analysis" mode.

Scintillation Detector

Both the alpha scintillation detector and the gamma scintillation detector are operated between 550 and 1,000 V. The alpha scintillation detector is normally operated in "window out" mode. Higher than required voltage will make the detector light sensitive and raise background excessively.

Gas Proportional Detector (Alpha Mode)

The GP detector can be operated at a lower voltage of 800 V to 1,200 V to record only alpha counts. Background may be higher than for a scintillation detector; therefore, minimum detectable concentration (MDC) and scan rates should be compared before a detector is chosen to minimize survey time.

Gas Proportional Detector (Alpha and Beta)

The GP detector can be operated at a higher voltage and lower threshold to record both alpha and beta counts. Caution should be exercised in this mode because the sensitivity for alpha activity is markedly reduced from the scintillation detector.

Single Channel Analysis

The scintillation detector can be set up to record counts from a single photopeak or energy range of interest. Contact the health physicist for information on setting up a single channel analyzer.

Threshold

The threshold setting is critical for all detectors. It should be raised to the point where background noise or photomultiplier dark current effects are minimized while detector efficiency is not affected. Refer to the manufacture literature for guidance on threshold setting for non-Ludlum detectors. The threshold dial is normally set so that a display of 100 is equal to a threshold of 10 millivolts (mV). Detector thresholds in mV are provided in Table 4. The threshold setting is not critical; however, higher thresholds may lower sensitivity, and lower thresholds will increase background.

Window Setting

When window "in" is selected, the detector acts as a single channel analyzer counting pulses between the detector threshold lower level discriminator and the threshold plus window width upper level discriminator. The window remains a constant width, and its lower level is established by the threshold setting. The window dial is normally set so that a display of 100 is equal to a threshold of 10 mV.

Dead Time

Dead time refers to the ability of the counters or detectors to account properly at high count rates for each interaction of the detector. Normally the dead time should not require adjustment for low-level activity measurements.

Response Time

Response time refers to the time constant of the visual rate meter indication circuit. A slow response time effectively integrates the count over a longer interval, resulting in a more stable indication. A fast response time allows the surveyor to note changes on the readout more quickly; however, random fluctuations are also more pronounced. Response time selection may be selected based on the preference of the surveyor. At low count rates, typical for alpha surveys, the slow response setting must be used.

Inspection

The instrument shall be inspected daily and the results noted on the daily check form prepared for each instrument. Inspections consist of the visual checks noted previously, a battery check, cable check and light leak check. A detector source response (accuracy) and precision (relative percent difference [RPD]) is measured and plotted daily.

DETECTOR SETUP

The following subsections discuss the methods of setting up each detector.

Counting Gas

Contact the health physicist for setting up gas flow counters. Have P-10 counting gas delivered to the site by a local industrial gas supplier. A two-stage regulator and standard gas fittings are needed. A low flow rate (0.1 to 5 liters per minute) flow meter is required.

Efficiency Determination

Efficiency determination is performed by determining the ratio of the count rate to the total number of emissions of the particle of interest. Division of the unknown sample count rate by this ratio will result in an estimate of the contained activity of the sample. The surface emission rate may also be available from the source calibration certificate. This factor is only used when correcting for backscatter effects when performing direct beta surface activity measurements.

Efficiency determination counting time may be longer than for field counts to improve the precision of the efficiency factor estimate. At least 20,000 counts should be collected for efficiency determination

Counting Geometry

Counting geometry must be constant between measurements and calibration. For swipe counting, a detector holder is available for both the 1-inch alpha scintillation detector and the lead shielded beta-gamma pancake detector. During calibration, the thickness of the source shall be accounted for in setting up the proper counting distance for subsequent counts. The sample holder shelf setting and source-to-detector-window distances shall be recorded. The recommended detector-to-source distance is 0.25 inch for alpha counting and use of the standard source holder in the highest position for beta counting.

Establishing Background

Background is determined for the purpose of computing net count rates. Each detector will have a location-specific background that will vary with counting location; therefore, background should be redetermined at each counting location for swipe counting and at least two times per day when surveying buildings where the background may vary. It is not required to measure background at several locations for surface activity measurements; however, the background should be taken where the detector is not influenced by surface contamination. Background count time influences the measurement sensitivity. For routine measurements, a ratio of sample count time to background count time of 1 to 10 is sufficient since sensitivity gains will be marginal beyond this.

For beta gamma instruments, background should be counted for not less than 10 minutes or 10 times the sample count time, whichever is greater. For low background rate instrument devices (shielded detectors or alpha scintillators), longer counting times (up to 60 minutes may be required) to optimize the detector sensitivity. Accumulation of 100 background counts is recommended with low background alpha detectors.

Uniformity

Determine that response is uniform by counting to 2 percent precision at the extreme ends of the detector. Consult the health physicist if the RPD is greater than 25 percent.

Recording Calibration Information

Each rate meter/scaler and detector pair, when calibrated with a specific source in a known background, is referred to as a case. Each case is assigned a unique identifier. Each case has a sample count time and derived values for detection level (L_d) and critical level (L_c). Cases are recorded on calibration record forms available from the health physicist. The unique case identifier must be listed on every sample data sheet.

Calculation of Control Limits

Control limits are calculated in accordance with standard statistical practices. Control limits are normally established at the start of each project for each detector and only repeated if the instrument or detector is repaired or otherwise determined out of control. Precision and accuracy control are discussed further in the following sections.

Precision Control

Precision or RPD is an indicator of the precision that the surveyor maintains from a pair of measurements of the same source. Use a source of sufficient activity to eliminate significant variation from counting statistics, and obtain 20 to 30 (n) repeated paired counts (40 to 60 counts). Calculate RPD and the confidence limits (CL) for the mean and prepare a control chart with t_{95} (warning) and t_{98} (tolerance) percent limits using the two-sided t-distribution.

$$\mathbf{RPD(\%) = 100} \times \left| (X_1 - X_2) / ([X_1 + X_2]/2) \right|)$$

$$\mathbf{CL} = \mu \pm \mathbf{t_{df}} \times \sigma / \sqrt{(\mathbf{n-1})}$$

Precision is checked daily using a single paired count and comparing this to the tolerance limits. Precision is a factor of both detector and surveyor. The surveyor should hold the detector manually over the check source when doing the daily check.

Accuracy Control

Accuracy is an indicator that compared to a NIST-traceable standard source, the detector response factor remains within expected tolerances. Accuracy control is maintained by developing a control chart from a series of 20 to 30 individual measurements of detector response and determining confidence limits for the mean and preparing 95 and 98 percent tolerance limit control points as described previously. Accuracy is principally a detector factor; however, a careless surveyor can affect accuracy by not maintaining proper surface to detector distances. This series of measurements should be done immediately after the efficiency calibration. The counting time shall be the same as for a field measurement.

Detection Limits

Detection limits specify the capability of a measurement system to detect a signal in the presence of a background or noise signal. Because all low level radioactivity measurements are associated with a physical error characteristic of the measurement process, statistical analysis is required for all measurements. Detection limits must be calculated at the field location where the survey is performed to account for background and to assure that the survey is of sufficient data quality for the intended purpose.

Pretabulated detection limits are available from the health physicist for a variety of count times and background rates. A Microsoft Excel™ spreadsheet for calculating these values is also available.

Discussion

Each measurement has an associated error determined by summing the associated error from the total signal and the background signal in quadrature. The magnitude of the error as well as the variability of the background signal determines the detection limits. Several key variables are associated with detection limits. These are discussed in the following text. Formulas for determining actual values are available from the health physicist. Detection capabilities are determined for each instrument at the start of the project, following on-site determination of field (building-specific) radiological background conditions and detector efficiencies. Detection limits based upon counting statistics considerations are calculated using the 95th percentile confidence interval for both Type I and Type II errors. Counting times will be adjusted as necessary to achieve required or specified detection limits.

Critical Level

Detection limits will be reported in terms of the critical level (L_C), which protects from the false positive or Type I error. The critical level activity concentration (less than values) is the *a posteriori* statement of detection, which when exceeded, indicates to some desired degree of confidence that the sample is different from background. The critical level is calculated as follows; the terms are defined in Attachment 3. All equations are summarized in Attachment 4.

$$L_C = \frac{K_a}{T_s} \times \sqrt{T_s r_b \left(1 + \frac{T_s}{T_b}\right)}$$

Detection Level

The detection limits (L_D) protects from the false negative or Type II error. The detection level is the *a priori* limit and represents the measurement system sensitivity. Detection level is denoted "L_d" and is the value stated in describing a measurement system. The detection level is calculated as follows; the terms are defined in Attachment 3.

$$L_D = \frac{K_a^2}{T_s} + \left[2 \times \frac{K_a}{T_s} \times \sqrt{T_s r_b \left(1 + \frac{T_s}{T_b} \right)} \right]$$

Reporting Criteria

The detection level shall always be lower than the radiological release criteria for all fixed point (direct) and swipe measurements. Detection limits will be reported in terms of both counts and reporting units (disintegrations per minute [dpm]/100 square centimeters [cm^2]) after conversion factors are applied. Maximum detection limits are the highest value acceptable for any detector configuration as determined under field conditions. The surveyor will adjust counting times to achieve detection limits equal or less than the specified values. The maximum detection limits established for this project in terms or fixed point (total) and swipe (removable) measurements are provided in the work plan. Detection limits for scanning should be lower than 25 percent of the average contamination limit for direct measurement as recommended (NRC 1992) (for example, 1,250 dpm/100 cm^2 for beta-gamma emitters) and less than 75 percent of the maximum limit for alpha emitters.

Reporting Data

Each measurement is reported as a net count rate and an error term or standard deviation. When the net count is below the critical level, the sample net activity is reported as less than either sample net activity plus the value of the one-sided 95 percent confidence interval or the critical level, whichever is greater.

$$Activity = r_s - r_b \pm K_B \sqrt{\frac{r_s}{T_s} + \frac{r_b}{T_b}}$$

$$Less\ than\ value\ (for\ r_s - r_b \leq L_c) = (r_s - r_b) + K_A \sqrt{\frac{r_s}{T_s} + \frac{r_b}{T_b}}$$

ACTIVITY MEASUREMENTS

Activity measurement methods using properly calibrated, set-up and in-control detectors are discussed in the following subsections. The surveyor shall start a new field data sheet for each case and record each measurement or scan using a unique identifier that identifies the location and type of measurement. Location codes are sequential numbers developed to identify reference locations. Location codes may be assigned during the survey or established during data entry. Code measurements with measurement type codes when recording each measurement in accordance with the following table.

Radiological Measurement Type Codes

Type	Code	Notes
Scan	S	indicate maximum as SM
Swipe	W	W1 denotes exactly 100 cm^2, WX may be greater area, WO indicates entire object was swiped
Fixed Count	F	
Duplicate	D	append to type code, i.e., WD, FD, SD, FAD
Average	A	always with fixed count, i.e. FA

Data may also be recorded directly on figures or sketches. A figure or sketch may be used to aid in location descriptions. If a series of counts is recorded on a sketch, record the starting sequential number and subsequent numbers completely (for example, -101/2475, -102/3128, -103/2332 [-sequential/count]) to distinguish the identifier from the count. Identify measurements on sketches as follows:

- Swipes by enclosing a sequence number in a triangle
- Fixed counts by enclosing in a circle
- Scans by enclosing the average and maximum in a square with a diagonal separator (average/maximum).

If more than one case is recorded on a sketch, preface each reading with the unique case identifier. A typical sample may be as follows:

AX0122xxxxxx [-223/2986FA]

where: AX is the case

0122 is the CTO

xxxxxx refers to other sample coding

-223 is the sequence for that location

2986 is the count (gross)

FA denotes a fixed count average.

Because the sketch will serve as the final record in many cases and will go in the final report, take extra care to be neat. Refer to the work plan for sample numbering requirements.

Count for the shortest time necessary to meet the required detection limits.

Transferable Radioactivity Measurements

Transferable surface contamination surveys shall be taken on floors, walls, equipment, and on representative items in the survey area, as described in the work plan.

The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wiping with an appropriate instrument of known efficiency as determined previously. When removable contamination of objects of less surface area is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. It is not necessary to use wiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels can be determined to be within the limits for removable contamination.

Transferable contamination shall be measured using a paper or cloth smear.

A. Use approximately 40-millimeter cloth or paper smears.

B. Swipe a 10- by 10-cm area as required.

C. Each smear shall represent an area of 100 cm^2 at the survey location.

D. Place the smear in an envelope that is labeled with the survey location, survey date, and the initials of the technician performing the survey.

E. Count smear with appropriate counting equipment to determine transferable contamination or submit to a laboratory for alpha-beta counting (specify the nuclide to laboratory).

F. Record smear sampling locations and count data

Field Alpha or Beta-gamma Counting of Swipes

1. Determine background count rate and source check alpha or beta-gamma counter.

2. Using tweezers, remove smear from envelope and position smear on sample tray in drawer of counter.

3. Close sample tray drawer and count sample for predetermined time.

4. Remove smear from sample tray drawer (using tweezers) and place in envelope from step (2) above. The health physicist will determine when smears can be discarded.

5. Record the net count rate on form.

   Net Count Rate (cpm) = Gross Sample cpm - Background cpm

   Calculate dpm/100cm^2 for sample as follows:

$$A = \frac{\frac{n_s}{t_s} - \frac{n_b}{t_b}}{\varepsilon}$$

   where the terms are defined in Attachment 3 of this SOP.

6. Calculate the minimum detectable activity (MDA) parameters.

TOTAL RADIOACTIVITY MEASUREMENTS

Total (fixed plus removable) surface contamination surveys shall be taken on floors, walls, equipment, and on representative items in the survey area, as described in the work plan. Detection limits for fixed counts shall be less than approximately 50 percent of the project numerical goal.

Fixed Counts

Determine the approximate count corresponding to the average and maximum activity limit before starting a survey as follows:

$$\textbf{average counts} \geq \textbf{count time} \times [\ (\textbf{Activity Limit} \div A_{CF}) + \textbf{background rate}]$$

$$\textbf{maximum counts} \geq \textbf{count time} \times [\ (3 \times \textbf{Activity Limit} \div A_{CF}) + \textbf{background rate}]$$

The fixed count points (nodes) are identified from gridding (discussed below), random points, and judgmental locations at the frequency identified in the work plan. At each location, using a suitable form, record the project, building and room, node designator, the surface type, the date and time of the survey, the surveyor, the instrument and detector calibration case. The surveyor will hold the probe at the detector-to-surface distance used in calibration for the required counting time. Counts may be made to preset intervals of 0.5, 1, 2, or 5 minutes as allowed by the scaler or by manual timing using a stopwatch or wristwatch for the time specified by the case. Record gross counts on the appropriate form.

If counts exceed the average value calculated above but less than the maximum value, a 1-square-meter area centered on the measurement location shall be counted. Record the measurements for averaging on the form provided and calculate the average activity using the following:

$$\textbf{probe areas required} = 1 + [10{,}000\ /\ \textbf{active probe area (cm}^2\textbf{)}]$$

$$\textbf{average gross counts} = (\Sigma\ \textbf{gross counts/probe area})/(\textbf{no. of probe areas})$$

Record the average measurement for the area and assign a sample number to the field calculated average.

Scanning Measurements

Review the scan MDC necessary for the survey. Determine the scan speed (always less than 3 cm/second for alpha) specified in the work plan or consult the health physicist. Turn up the rate meter audible indicator and adjust the meter response time to slow. Set the range so background is at the low end of the scale.

Assign two sample numbers to each scan area. Scan areas no larger than 1 m^2 at a time. Record the average response and maximum response for the area. Areas close to (greater than 50 percent of) the numerical goals as calculated previously should be determined by a fixed time count. The surveyor will slowly scan while listening to the audible rate as well as watching the rate meter.

Special Considerations for Alpha Scanning

Because of Poisson[2] probabilities governing the statistics of low activity alpha counting when scanning, special considerations are required. When alpha scanning, the surveyor will stop after any single audible count and determine the counts in 0.1 minute (6 seconds). If the counts equal or exceed the limit value determined previously, recount for 30 seconds. A field decision to fail an area based on alpha counting should be based on a count at least as long as required to meet the L_D.

QUALITY CONTROL

Refer to the project quality assurance and quality control plan for project-specific details.

Instrument Control

Instrument control measurements provide a means to document that each detector and rate meter/scaler pair is responding correctly from day to day. Instrument control charts are checked as part of the data validation procedure. Each required instrument control measure is described in the following text.

[2] Poisson statistics describe a distribution for rare events such as radioactive decay. They are also used to model occurrences in everyday life such as cars arriving at toll booths. Above about 25 events, the Poisson distribution approaches the binomial distribution.

Precision Control

After the detector is set up, each surveyor shall obtain a daily paired measurement of a check source and plot their RPD daily for each type of measurement. The counting times and source activities must remain constant for each detector setup for this test.

Accuracy Control

After the detector is set up, each surveyor shall obtain a daily paired measurement of a check source and plot their RPD daily for each type of measurement. The counting times and source activities must remain constant for each detector setup for this test.

Out of Control Action

Control charts are constructed at the 95th percentile (warning) and 98th percentile (tolerance) t-distribution, thus 5 measurements out of 100 will exceed the warning (95 percent) control limit. The surveyor should note any trends in the data as well as excessive points beyond the warning and any data beyond the control limit. Two consecutive points or three of ten points beyond the tolerance limit requires that the detector be taken out of service and recalibrated.

Duplicate Counts

Duplicate counts will be performed on at least 10 percent of fixed counts and swipe counts. All duplicate sample counts shall be recorded with the location identified and coded as duplicate samples.

AREA GRIDDING AND DESIGNATION

Establish 1-meter-square grids in affected areas. Snapping chalk lines is preferred for small rooms. Note north-to-south lines A, B, ...T, AA, AB. Note east-to-west lines 1, 2, 3... Note vertical planes at ground W, 1 meter as X, 2 meters as Y, XA, XB, and ceiling plane as Z. Contiguous rooms may use the same grid. Start a new notation for noncontiguous rooms.

Two perpendicular walls shall serve as the starting lines of reference for the starting grid lines.

Affected Areas

Affected areas are designated Class I areas in accordance with MARSSIM terminology. Normally node measurements are made at each node for alpha and beta fixed counts. Node measurements are made on walls in the W, X, and Y planes. Ceilings are optional as discussed in the work plan. Swipes may be taken from alternate nodes or randomly to meet numerical sample requirements. Collect judgmental swipes at the direction of the health physicist.

Unaffected Areas

The survey frequencies for MARSSIM Class II and Class III areas will be designated in the work plan.

Survey Maps

Use forms provided by the health physicist to record field data, room sketches, and notes. Code individual measurements as discussed previously to avoid ambiguity of data. Establish orthogonal facility coordinates and designate them on a general facility arrangement sketch.

Location Designation

Each grid node will have a unique location code[3] to reference all measurements made on that node or within the grid. Nodes refer to the intersection of grid lines. Areas within the grid are referenced to the lowest possible grid values (a before b, 1 before 2) from the bounding lines, numbering from the northernmost and easternmost corners.

DETECTION LIMITS AND REPORTING

Data Reporting and Sample Size Correction. Swipes of areas less than 100 cm^2 are reported "per item." Swipes of areas greater than 100 cm^2 are reported per 100 cm^2. Where swipes of greater than 100 cm^2 exceed criteria, the suspect area is resurveyed using 100 cm^2 swipes.

Detection Limits. Survey parameters will be adjusted so that the activity detection level does not exceed the project requirements. Specific maximum values for detection limits shall be specified in the work plan.

[3] The location code is used with the database.

TABLE 1
DETECTOR OPERATING CHARACTERISTICS

Detector Type	Application	Typical Model	Surface Area (cm^2)	Window Thickness (mg/cm^2)	Calibration Standard	Sensitivity
AS	α Swipe Counting	One-inch diameter	1	0.8	230Th	good
AS	α Surface Scans	100 cm2 probe	100	0.8	230Th	good
GM	β-γ Swipe counting	lead shielded pancake	15	1.7	36Cl, 99Tc	good
GM	α Surface scans	unshielded pancake	15	1.7	230Th36Cl, 99Tc	poor
GM	β-γ Surface scans	unshielded pancake	15	1.7	36Cl, 99Tc	poor
GM	α Surface scans	unshielded pancake multidetector configuration	60	1.7	230Th	good
GM	β-γ Surface scans	unshielded pancake multidetector configuration	60	1.7	36Cl, 99Tc	good
GP	α Surface scans	hand-held	100	0.8	230Th	good
GP	β-γ Surface scans	hand-held	100	0.8	36Cl, 99Tc	good
GP	α Surface scans	floor monitor	400	0.8	230Th	very good
GP	β-γ Surface scans	floor monitor	400	0.8	36Cl, 99Tc	very good
S	γ Walkover	hand-held	--	--	137 Cs	very good

Notes:

Cl	Chlorine
Cs	Cesium
Tc	Technitium
Th	Thorium
cm^2	centimeters squared
mg/cm^2	milligrams per centimeter squared

TABLE 2
SURFACE RADIOACTIVITY LIMITS FOR RELEASE OF MATERIALS

Radionuclides[2/]	**Allowable Total Residual Surface Contamination (dpm/100 cm²)**[1/]		
	Average[3/4/]	**Maximum**[4/5/]	**Removable**[4/6/]
Transuranics, I-125, I-129, Ra-226, Ac-227, Ra-228, Th-228, Th-230, Pa-231	100	300	20
Th-nat, Sr-90, I-126, I-131, I-133, Ra-223, Ra-224, U-232, Th-232	1,000	3,000	200
U-nat, U-235, U-238, and associated decay products	5,000	15,000	1,000
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.[7/]	5,000	15,000	1,000

1/ As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

2/ Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

3/ Measurements of average contamination should not be averaged over more than 1 m^2. For objects of less surface area, the average should be derived for each such object.

4/ The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h or 1.0 mrad/h, respectively, at 1 cm.

5/ The maximum contamination level applies to an area of not more than 100 cm^2.

6/ The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wiping with an appropriate instrument of known efficiency. When removable contamination of objects of less surface area is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. It is not necessary to use wiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination.

7/ This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them. It does not apply to Sr-90 which has been separated from other fission products or mixtures where the Sr-90 has been enriched.

Notes:
dpm/100 cm^2 Disintegrations per minute per 100 centimeter squared
Source: USNRC Regulatory Guide 1.86, June 1994.

TABLE 3
SELECTION OF COUNT PRECISION BY TOTAL COUNTS ACCUMULATED (FOR 10,000 CPM BACKGROUND)

Counting Time (min)	Counts (n) (10,000 cpm background)	Counting Error (1σ) (counts)	Precision (2σ) (%)[a]
< 0.01	4	2	98.00%
< 0.01	16	4	49.00%
< 0.01	25	5	39.20%
< 0.01	64	8	24.50%
0.01	100	10	19.60%
0.04	400	20	9.80%
0.17	1,600	40	4.90%
0.27	2,500	50	3.92%
0.5	4,500	67	2.92%
0.9	9,000	95	2.07%
1	10,000	100	1.96%
4	40,000	200	0.98%
5	45,000	212	0.92%
17	160,000	400	0.49%
27	250,000	500	0.39%

Notes:

a	coefficient of variation (%) = $100 \times Z_s (r_s \times T_s)^{1/2}/(r_s \times T_s)$
cpm	counts per minute
n	the number of counts
Z_s	standard normal deviate 95th percentile
$r_s \times T_s$	product of rate (r_s) and time (T_s) is n

TABLE 4
DETECTOR SETUP PARAMETER CHARACTERISTICS

Application	**Model Number**	**Voltage**	**Threshold (mV)**	**Window (mV)**	**Efficiency (percent 4π)**		
	Ludlum Inst.				α	β	β-γ
α Swipe Counting	44-2	600	30	--	15	--	--
α Surface Scans	44-90	600	30	--	15	--	--
β-γ Swipe counting	44-40	900	35	--		20	30
α Surface scans	43-37	1250	40	--	17	--	--
α Surface scans	43-20	1250	40	--	17	--	--
β-γ Surface scans	43-37	1750	4	40-60	--	20	30
β-γ Surface scans	43-20	1750	4	40-60	--	20	30
γ Walkover	44-10	900	25		--	--	--

Notes:

mV milliVolt

ATTACHMENTS

ATTACHMENT 1
REQUIRED DATA FOR DETECTOR CALIBRATION

Table Name: case information File Name: case_inf

FIELD NAME	DATA TYPE	DATA FORMAT	SPECIAL	DESCRIPTION
case number	code	text	unique	
project code	code	text	match, required	
scalar code	code	text	match, required	
detector code	code	text	match, required	
calibration date	data	text	required	last calibration date
narrative info	data	text		addition information
background count	data	number	required	counts
background count time	data	number	required	minutes
sample count time	data	number	required	minutes, for all data collected under this case
detection limit	data	number	required	L-d count per minute
critical value	data	number	required	L-c
calib by	code	text	match, required	calibration performed by
source activity	data	number	required	calibration information, from source table
source count	data	number	required	calibration information
source count time	data	number	required	calibration information
cal. Background count	data	number	required	calibration information
cal. Background count time	data	number	required	calibration information
cal mod factor 1	data	number	default is 1	calibration information
cal mod discussion	data	text		discuss the cal mod factors, geometry, backscatter, etc.
efficiency	data	number	required	calibration information
area factor	data	number	required	calibration information
detector area	data	number	required	calibration information, from detector table
activity conversion factor	data	number		multiplicative value to convert count data to activity data
activity reporting units	data	text		activity data units used (pci, dpm, dpm/100 cm^2 , etc.)
activity detection limit	data	number		
activity critical value	data	number		
cal source id	data		match, required	

Table Name: location information File name: Loca_inf

FIELD NAME	DATA TYPE	DATA FORMAT	SPECIAL	DESCRIPTION
location code	code	text	unique	physical sample location identifier, usually sequential
building number	data	text	required	building identifier or other description
building description	data	text	required	
room number	data	text		
room description	data	text		
grid northing	data	text	required	reference to grid system used
grid easting	data	text	required	
actual northing	data	text		reference to coordinate system
actual easting	data	text		
grid reference	data	text	required	describe grid reference used, for multiple grids identify as grid A, B, ...
actual reference	data	text		

ATTACHMENT 2
GENERAL REFERENCES

The following references may be consulted for additional information.

American Society of Testing and Materials. Standard Practice for Sampling Surface Soils for Radioactivity. C998-90. Philadelphia, PA.

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U.S. Nuclear Regulatory Commission (NRC). 1977. Appendix I, 10 CFR 50. 44 Federal Register. September 28.

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NCRP. 1989. Screening Techniques for Determining Compliance with Environmental Standards.

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ATTACHMENT 3
DETECTION LIMIT TERM DEFINITIONS

K_a	=	1.645 (one-sided 95 percent standard deviation)
K_b	=	1.96 (two-sided 95 percent standard deviation)
T_s	=	Sample count time
T_b	=	Background count time (at least 10 Ts)
n_b		Background counts
n_s		Sample counts
r_b	=	Background count rate
r_s	=	Sample count rate
ad	=	Detector area (cm^2)
ε	=	Efficiency
cpm	=	Measured net count rate (count per minute)
dpm	=	Source activity or measurement result (disintegration/minute)
L_c	=	Critical level
L_D	=	Detection limit
MDC	=	Minimum detectable concentration
A_{cf}	=	Activity conversion factor
r_{source}	=	Net count rate of a standard source using contained activity from source certificate
f_i	=	other correction factors

ATTACHMENT 4
STANDARD CALCULATIONS

Critical Level L_C

$$L_C = \frac{K_a}{T_s} \times \sqrt{T_s r_b \left(1 + \frac{T_s}{T_b}\right)}$$

Detection level L_D

$$L_D = \frac{K_a^2}{T_s} + \left[2 \times \frac{K_a}{T_s} \times \sqrt{T_s r_b \left(1 + \frac{T_s}{T_b}\right)}\right]$$

Activity

$$A_{dpm/100cm^2} = \left(\frac{n_s}{t_s} - \frac{n_b}{t_b}\right) \times A_{CF} \pm \left[A_{CF} \times K_B\right] \times \sqrt{\frac{r_s}{t_s} + \frac{r_b}{t_b}}$$

Activity Conversion Factor

$$A_{CF} = \frac{1}{\varepsilon_\varepsilon} \times \frac{\text{area}_{100}}{\text{area}_d}$$

Efficiency

$$\varepsilon_\varepsilon = \frac{r_{source}}{\left(\frac{n_{cal}}{t_{cal}} - \frac{n_{b-cal}}{t_{b-cal}} - \right)} \times f_1 \times f_2 \times f_3 \bullet\bullet\bullet$$

ATTACHMENT 5
Statistical Reference

Chi Square (χ^2)
Area in upper tail

df	**1**	**5**	**10**	**15**	**20**	**25**	**30**	**40**
χ^2	3.84	11.07	18.31	24.99	31.41	37.65	43.77	55.76

t distribution (*t*)
Area in one tail (0.05)

df	**1**	**5**	**10**	**15**	**20**	**25**	**30**	∞
t	6.31	2.01	1.81	1.75	1.72	1.7	1.69	1..645

t distribution (*t*)
Area in two tails (0.05)

df	**1**	**5**	**10**	**15**	**20**	**25**	**30**	∞
t	12..70	2.57	2.23	2.13	2.08	2.06	2..04	1..645

Area in two tails (0.02)

df	**1**	**5**	**10**	**15**	**20**	**25**	**30**	∞
t	31.82	3.36	2.76	2.60	2.53	2.48	2.46	1..645

EXPOSURE RATE SURVEYS AT 1 METER IN OUTDOOR AREAS USING GLOBAL POSITIONING SYSTEM

Title: EXPOSURE RATE SURVEYS AT 1 METER IN OUTDOOR AREAS USING GLOBAL POSITIONING SYSTEM

1.0 BACKGROUND

Walk over surveys are used to provide preliminary classification of an areas radiological status, to locate and remove radiation anomalies (hot spots), and to document final status of a site.

1.1 PURPOSE

The purpose of this standard operating procedure is to describe the methods used to conduct walk over and exposure rate (final status) surveys using global positioning system (GPS)-capable radiation data recording systems. The purpose of this SOP is to describe the methodology for measuring gamma-ray exposure rates in preremedial and postremedial action areas, inclusive of open land areas and other outdoor structures.

1.2 SCOPE

This procedure includes a description of the appropriate methods used to perform surveys and use of the GPS system to record radiation data and geographic information. Use of the GPS and field datalogger is covered elsewhere. This procedure includes a description of the techniques and instrumentation used during such exposure rate determinations. All measurements are to be made in the prescribed manner at 1 meter above the ground or floor where applicable.

1.3 DEFINITIONS

Circular Error Probability (CEP). A statistical measure of the likelihood of a measurement being within a specified value of the true value. A CEP (95 percent) means that 95 percent of the time, a measured value is within a specified distance of the true location.

Final Status Survey. A final status survey is conducted after all remediation at a survey unit (portion of a site) is complete. The final status survey report serves as the final documentation of radiation exposure rates, soil radioactivity concentrations, and residual surface radioactivity. The final status survey is conducted before the property can be transferred or released for unrestricted use.

1.4 REQUIREMENTS AND RESOURCES

All equipment is properly calibrated by the vendor or as described in calibration SOPs, and calibration records are available to the user.

A Trimble™ Pro XR Differential capable GPS receiver and TDC 2 datalogger with Asset Surveyor™ software and connecting cables is operational.

A suitable radiation detector with rate meter/scaler and RS-232 interface with ASCII digital output is available.

1.5 EQUIPMENT AND MATERIALS

A. Site maps and drawings of areas to be surveyed
Grid overlay with node designations to scale of site maps

B. Grid Markers and Measuring Tape
Stakes, flags, or metal spikes with numbered brass tags or identifier codes stamped on stakes
100-foot measuring tape

C. Gamma-Ray Exposure Rate Survey Form

D. Portable Rate Meter/Scaler (Ludlum 2221 or equivalent)

E. Gamma Scintillation Detector (Ludlum 44-10 2 inch by 2 inch NaI (Tl) or equivalent)

F. Reuter-Stokes Pressurized Ionization Chamber (PIC) if required by work plan

G. Trimble Pro XR and TDC2

2.0 PROCEDURE

This section discusses personnel responsibilities and the steps involved in conducting a walk over survey using GPS.

2.1 RESPONSIBILITIES

The following subsections outline the responsibilities of key personnel responsible for implementation of this procedure.

2.1.1 Supervisor

The supervisor is responsible for overall implementation and quality assurance of measurements.

2.1.2 Technician

The technician is responsible for instrument setup, data collection, data transfer, and equipment maintenance.

2.1.3 GPS Specialist

The GPS specialist is an integral part of the survey team. The GPS specialist is responsible for proper operation of the system, oversight of data transfer, data processing and validation, receiver set-up testing, and addressing problems.

2.2 USE OF GLOBAL POSITIONING SYSTEM

The following sections address the use of GPS for radiation survey measurements.

2.2.1 Overview

The GPS system provides exact position information in digital form approximately once every second. The data collector logs position information, time, radiation detector signal, and user input parameters, at intervals selected by the user. After a survey, data are transferred to a computer for processing, review, validation, and transfer to the Geographic Information System (GIS). Manual data recording is unnecessary. A record of the survey areas covered and the surveyors ground speed are recorded, and higher quality data are produced than would be practicable for a manual type of survey.

2.2.2 Base Station

A base station monitors the satellite system and provides data enabling correction of the signal recorded by the portable (rover) unit. Correction is performed in postprocessing, by loading the base station data and rover data into a software program. Within California, two base stations are available: one in Sunnyvale and one in Ridgecrest. The Ridgecrest station is operated by the Navy. Data are available over the Internet from the Trimble computer server (HTTP:\\www.trimble.com). Dilution of precision occurs at about one part per million per mile, and the recommended range is within 300 miles of either station. Alternatively, a user may establish a base station at any accurately known location and generate independent correction data.

2.2.3 Differential Signal

A differential signal is a real-time corrective signal broadcast over either public or private channels. The net effect of using a differential signal is to improve the real-time accuracy of GPS from about 100 feet with selective availability (SA) to within 5 feet. Differential signals are available in coastal California from the U.S. Coast Guard (USCG) transmitters. Alternatively, a user may establish a transmitter if a differential signal is not otherwise available. Most survey and mapping applications do not require real-time accuracy to less than 10 feet CEP; therefore, a transmitter is not normally used. Real-time differential data accuracy can be improved by postprocessing as discussed previously in the base station section.

2.2.4 Accuracy

With a differential signal (USCG or private beacon), real-time accuracy for placing grids within about 1 meter (CEP) is available. Without a differential signal, accuracy is dependent on SA, which varies at will by U.S. Department of Defense (DoD); therefore, accuracy is within 200 feet and may only be relied on for setting up very large scale grids. With a community base station, however, the differential correction may be applied during postprocessing, and submeter accuracy is recovered. If higher order precision is required, request the GPS specialist to make carrier phase (CP) measurements at several locations including one USGS benchmark. CP measurements require a 20 minute occupancy time and special postprocessing; however, positional accuracy to better than 30 cm can be achieved.

2.2.5 Coordinate Systems

Normally, the GPS receiver/data recorder is programmed to provide positions in California State Plane Zone 3. If other areas are required, notify the GPS specialist in advance to have the unit programmed.

2.2.6 Waypoints

Waypoints may be developed for a "go-to" navigation screen to aid the surveyor. The normal convention is to select a base and calculate offsets on a fixed spacing. Northing offsets are designated 1,2,3, etc., and eastings are designated A, B, C, etc. Excel formulas for calculating offsets for any angular baseline from true north are provided as an attachment. Waypoints are transferred to the TDC2 in the format below:

"easting, northing, elevation, waypoint name"

An example is: 100.0001,2234.0022,0.0,"grid501A11"CRLF
where each line is an ASCII representation and the grid name is enclosed in double quotes, each value is comma delimited and ends in a carriage return/line feed ASCII code "ODOA" (in hexadecimal notation).

2.2.7 Data Interface

The radiation detector (scaler/rate meter) continuously updates the data bus in rate meter mode and updates the data bus after each count in scaler mode. Data are transmitted at 9600 baud, 8 data bits, 1 stop bit, no parity bit in the ASCII format "Nxxxxx" where xxxxx is the count value, and N is a letter corresponding to R for rate, A for a 0.1-minute timed count, B for 0.2 minute, C for 0.5 minute, D for 1 minute and so forth. A nine pin "Y" cable is used between the rate meter/scaler and the TDC 2, making the signal available to both ports of the TDC 2 data recorder. Only pins 2 and 5, signal ground and signal transmit of the RS-232 interface, are needed. The GPS specialist will configure the TDC 2 to accept these data. A check may be made on proper rate meter/scaler operation by reading the output using the terminal program of a portable computer.

2.3 USE OF DATALOGGER

Consult the GPS specialist to configure the GPS and datalogger. Several options are available will affect the volume and quality of data.

Consult the GPS specialist to establish a data dictionary that will record the date and time of the reading, the surveyor, the type of cover (soil, asphalt, concrete), the grid node, measurement details, and special notes.

All information recorded including position, sensor values, and user notes will be transferred to a portable computer daily, and a backup 3.5 inch high-density diskette copy will be made. A manual record will be kept which will include the datalogger filename, the file name and directory, and the backup file name and disk identifier.

Users should keep files small, up to 100 survey points, download regularly, and check data and results regularly.

2.4 USING SURVEY GRID WAYPOINTS

Waypoint is simply a pair of coordinates and an identifier. Waypoint navigation using GPS eliminates use of a compass, compass error, and magnetic declination to true heading conversions. Using the NAVIGATION SCREEN, select a navigation method and a waypoint. The user must practice to move continuously at a slow walk when using these screens. Using coordinates, the user will be prompted to go north x feet and east xx feet to the waypoint. Trial and error are used to establish true north. Using the bearing, the user is given a heading and a distance to go. The user's true heading is also provided. If a starting coordinate or waypoint and ending waypoint are given, the user can navigate using track error (distance left or right of the intended track). By picking suitable waypoints, the corners of a grid can be readily located and flagged.

2.5 INSTRUCTIONS

A. Exterior Surveys

1. A grid for the area to be surveyed shall be created before any measurements are taken. The grid may be set up by a surveyor, by tape and compass, or by differential corrected GPS. The method to be used shall be determined by the site supervisor.

2. Verify the operational status of all field instrumentation. Some instruments will require a 24-hour charge before field use. Response check and background check all instruments. Compare the detector response with expected readings (based on initial calibration). Document all checks.

3. Predetermine the number of survey locations required to adequately survey the entire area. This is a judgment call based on the required grid spacing, and coverage and should be discussed with the health physicist. Determine whether the use of a the pressurized ion

chamber (PIC) is required and if exclusive reliance on the PIC is practical. Should there be numerous measurements, the Ludlum 44-10 will be cross calibrated to expedite the survey process.

4. Perform a cursory walkover survey, and in conjunction with the background data, determine five locations to provide a range from lowest to highest count-rate for cross calibration of the specific detector. Use the Ludlum 44-10 for exposure rate surveys where correlation with the PIC will be performed. Select at least 5 locations (up to 15 locations) and make PIC measurements and 44-10 measurements, carefully centering the detector at 1 meter elevation. Make sure that measurements encompass the entire range for exposure rates in the survey area.

5. Relate the count rate to the PIC exposure rate using a line fitting algorithm and determine the cpm to milliroentgen per hour (mR/hr) slope and error estimate.

6. Once instrument correlations have been established, all remaining gamma-ray exposure rates may be determined using the appropriate scintillation detector. All exposure rate determinations conducted shall be determined by counting to the desired variance to minimize counting statistical variation. All measurements shall also be conducted at 1 meter above the ground. Exposure rate surveys with the PIC shall be conducted for a minimum of two integration periods and at 1 meter above the ground.

Note: Accurate timing is essential when making exposure rate determinations with the PIC. Actual start time to the second should be noted for time integrated exposure determinations. After the survey, the technician shall wait for an actual integration and document the actual time to the second. The following formula is used to calculate exposure rate with the time integrated data.

INTEGRATION mR / SURVEY TIME SECONDS X 360 = mR/hr

B. Interior Surveys

1. During some characterization or remedial action activities, exposure rate surveys may be required in buildings or structures. The method for conducting these types of surveys is the same as exterior surveys; however, cross calibrations with the PIC may not be practical in the structure. In the event cross calibration in interior areas is not possible, cross calibrations may be conducted before entry in exterior areas where contamination types are the same and a range of exposure rates is present. (Note: GPS cannot be used indoors.)

2. Before survey measurements, conduct operational checks on all instrumentation. Conduct cross calibrations if required. The health physicist will determine the survey requirements for the interior survey.

3. Survey all areas within the structure to adequately determine exposure rates. Make all measurements at 1 meter above the floor surface or as directed by the health physicist.

4. Document all survey data using the datalogger, and prepare a data report daily.

C. Quality Control

1. Take a duplicate measurement for one in every twenty (20) measurements obtained with each detector.

2. The locations for duplicate measurements shall be at the twentieth survey location wherever the location.

3. Duplicate measurements shall be documented on the same form and identified as a duplicate (D).

2.6 OTHER CONSIDERATIONS

1. Instruments used to be capable of detecting the gamma ray energies present. Serious errors will occur if a PIC is used to measure the exposure rates from low energy gamma emitters (americium-241 or depleted uranium).
2. Discordant data observations (outliers) are fairly common when attempts to cross correlate detectors are made in the field. Consequently, exposure rates measured with gamma scintillation detector should be regarded as estimates.

2.7 WALK OVER SURVEY PROCEDURE

The surveyor shall work at a speed of 1 to 2 feet per second and slowly swing the detector side to side while advancing. The swing shall encompass 30 inches, and the detector must be kept low to the ground. Between nodes (between recording point, line or area features), the datalogger will record the position every second or at a longer interval and the sensor value at a selected interval (every second or longer).

2.8 SOIL SEGREGATION

The sodium-iodide detector may be used to segregate soil provided a sufficient volume of soil is collected. At least 8 liters of soil should be selected and placed in a bucket. Select a low background area for counting soil, and count background and each sample for 5 minutes, placing the detector in Marinelli[1] configuration for the soil counting. Convert count rate to activity using a factor of 800 cpm per picocurie per gram, or use a factor derived by the health physicist.

2.9 MEASUREMENT INSTRUCTIONS

A systematic grid shall be established (if a GPS system is not utilized) before any radiological surveys or sampling are conducted. This grid may be in meters or feet as directed by the health physicist.

[1] A physical counting geometry where the detector is placed inside the sample volume.

Once the survey grid has been established, initial surveys may begin. A walk over gamma survey should be conducted on sites where gamma-emitting contamination was present. This survey shall be conducted with a scintillation detector. Results of this survey shall be documented with emphasis placed on documentation of hot spots.

Data plotted in relation to the grid shall include all characteristic information such as buildings, ditches, mounds, or any other object which may assist in the evaluation of the survey.

After completion of the initial walk over gamma survey, areas that appear to not meet criteria shall be excavated. Once hot spot excavation is completed, these areas should be resurveyed, and documentation shall reflect these changes.

If soil contamination is of the nature that gamma surveys are not practical, conduct systematic soil sampling over the property.

2.10 DOCUMENTATION

Record all measurements using the appropriate form or a generic grid map as specified by the health physicist. Averaging surface contamination measurements will be required whenever postremedial action surveys are conducted on concrete floors, etc. Technicians are required to review all survey data on a daily basis with the health physicist to assure remedial action guidelines have been met.

Grid Spacing Calculations

Use these formulas to compute uniform grid nodes with spacing width, offset from the state plane coordinate system "B5" degrees in angular measure. A spreadsheet application example follows.

northing coordinate formula

=no+(IF(J9<0,(-1*(SQRT((((I9*width)^2) + ((J9*width)^2))))),SQRT((((I9*width)^2) + ((J9*width)^2))))*SIN(RADIANS(IF(J9=0,90,DEGREES(ATAN(I9/J9)))-B$5)))

easting coordinate formula

=eo+(IF(J10<0,(-1*(SQRT((((I10*width)^2) + ((J10*width)^2))))),SQRT((((I10*width)^2) + ((J10*width)^2))))*COS(RADIANS(IF(J10=0,90,DEGREES(ATAN(I10/J10)))-B$5)))

where:

no and eo are the northing and easting origins

width is the cell spacing

I9 and J9 are the offsets corresponding to row and column a ... i and 1 ... j

b$5 is the offset angle

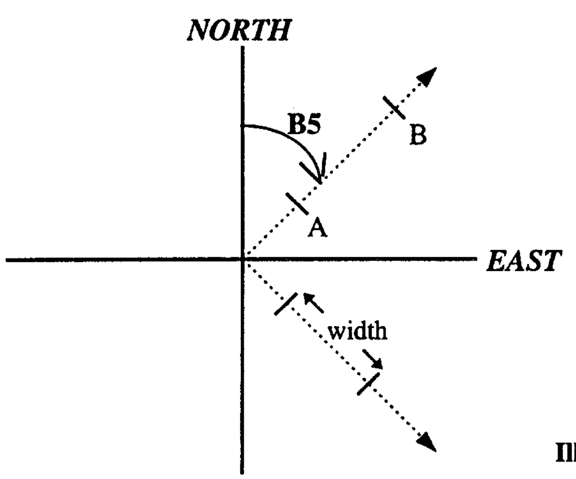


Illustration of Coordinate System

Excel formulas

used for angle calculation, do not change row 1 to 8

sheet 2 is the data to export, the format for trimble is easting, northing, elev, "pointname" must be in double quotes

north	**100**	**141.4**	*=C2-B2*	delta north			
east	**100**	**141.4**	*=C3-B3*	**=90-DEGREES(ATAN(D2/D3))**	angle between grids	=IF(J9=0, 90,DEGREES(ATAN(I9/J9)))	
grid width feet	**20**			off	off		
angle deg	=I3	510					
enter north origin	enter east origin						**angle point**
100	100					**10.53**	
base north	**base east**	**angle**	**name**	**north offset**	**east offset**	**northing**	**easting**

Sample Grid Cells

=$I$3	I	1	I	1	**=TEXT(page,0) & TEXT(D17,0) & TEXT(E17,0)**	=TEXT(CODE(F17),0)-65	0	=no+(IF(J17<0,(-1*(SQRT((((I17*width)^2) + ((J17*width)^2))))),SQRT((((I17*width)^2) + ((J17*width)^2))))*SIN(RADIANS(IF(J17=0,90,DEGREES(ATAN(I17/J17)))-B$5)))	=eo+(IF(J17<0,(-1*(SQRT((((I17*width)^2) + ((J17*width)^2))))),SQRT((((I17*width)^2) + ((J17*width)^2))))*COS(RADIANS(IF(J17=0,90,DEGREES(ATAN(I17/J17)))-B$5)))

=$I$3	A	4	A	4	**=TEXT(page,0) & TEXT(D39,0) & TEXT(E39,0)**	=TEXT(CODE(F39),0)-65	=G29	=no+(IF(J39<0,(-1*(SQRT((((I39*width)^2) + ((J39*width)^2))))),SQRT((((I39*width)^2) + ((J39*width)^2))))*SIN(RADIANS(IF(J39=0,90,DEGREES(ATAN(I39/J39)))-B$5)))	=eo+(IF(J39<0,(-1*(SQRT((((I39*width)^2) + ((J39*width)^2))))),SQRT((((I39*width)^2) + ((J39*width)^2))))*COS(RADIANS(IF(J39=0,90,DEGREES(ATAN(I39/J39)))-B$5)))

Title: SOURCE HANDLING REQUIREMENTS FOR LICENSED SOURCES

1. BACKGROUND

The area of transportation, handling, and storage of licensed radioactive sources is highly regulated; therefore, strict compliance with federal and state regulations is mandatory. In addition, federal law may impose fines on company employees directly for noncompliance during the transportation of radioactive materials, including transportation or offering for shipment to a carrier. This procedure supports the Tetra Tech EM Inc. (TtEMI) license issued by the California Radiological Health Branch (RHB) for possession of licensable radioactive material.

1.1 PURPOSE

This standard operating procedure (SOP) sets forth the procedures TtEMI employees will follow when using or transferring radiation sources to temporary locations as authorized by TtEMI's State of California radioactive materials license Number 6062-90.

1.2 SCOPE

This SOP applies to all TtEMI users of licensed radioactive sources within the state of California. The requirements set forth herein have been incorporated within TtEMI's radioactive materials license and may not be altered or modified without written approval of the RHB.

1.3 DEFINITIONS

The following definitions are needed for this document:

Radiation Safety Officer (RSO): responsible individual named on a specific radioactive materials license.

California Radiological Health Branch (RHB): state agency responsible for issuing TtEMI a radioactive material license.

1.4 REFERENCES

The following references apply to this SOP:

- U.S. Department of Transportation (DOT), Research and Special Programs Administration, Title 49, Code of Federal Regulations (49 CFR).

1.5 REQUIREMENTS AND RESOURCES

49 CFR: DOT, Rules and Regulations for Transportation of Radioactive Material

2. PROCEDURE

This section discusses personnel responsibilities and the steps involved in using and transporting licensed radioactive sources.

2.1 RESPONSIBILITIES

On-site health and safety officer (OHSO): Each OHSO is responsible for the on-site auditing of the radioactive material user for compliance with this procedure.

Health and safety coordinator (HSC): The HSC maintains accountability records for licensed radioactive sources and maintains a list of authorized users of licensed radioactive material.

Health and safety program manager (HSPM): The HSPM is responsible for management of the TtEMI radiation safety program and may be assigned duties of the RSO when named on the license to possess radioactive material.

Radioactive Materials User (USER): The USER is responsible for compliance with all aspects of this procedure at all times.

2.2 AUTHORIZED USERS

The TtEMI license authorizes the RSO and only the users designated by the RSO as licensed radioactive material users to handle licensed sources after completion of classroom training and a satisfactory examination. The RSO shall designate authorized users in writing. Responsibilities of authorized users cannot be delegated to others.

2.3 STORAGE LOCATIONS

Only the RSO may approve temporary storage locations for use overnight or longer. Such approval is documented in a memoranda or site-specific health and safety plan supplement and will be valid for up to 1 year unless renewal for longer periods is requested by the project. The HSC will maintain a record of all approved temporary storage locations. Approval will be based upon consideration of security, provisions for securing sources, and public access.

2.4 SECURITY IN TRANSPORT

Sources will be secured in a locked trunk or closed cargo area during transport and protected from damage in a secondary case or packaging equivalent to the manufacturers original shipping container. Physically small sources may be secured in 1-gallon paint pails surrounded by suitable padding. Larger sources may be placed in rugged packing cases or original packaging. Containers transported in open pickup truck beds shall be secured to prevent loss or theft using a padlock and chain connected to an engineered attachment point (that is, a handle which is generally a satisfactory means of security). TtEMI sources do not require radiation shielding in transport.

2.5 SECURITY AT TEMPORARY WORK LOCATIONS

Sources will be maintained either (1) within the immediate control of the authorized user or (2) in a secure location. Secure locations are as follows:

- In a transit secure location as described in Section 2.4 for transport, but not overnight
- In a storage area approved as described in Section 2.3
- In a locked and secured container at the point of use for up to 12 hours during the workday
- In any other specific manner approved in writing by the RSO

Sources will not be stored at any employee's residence.

2.6 SHIPPING PAPERS

Shipping papers listing the source(s) in transit shall be carried with the authorized user in the manner proscribed by 49 CFR. Shipping papers shall be submitted to the RSO for review before use. A shipping paper may be reused for transporting the same source and need not be prepared over again. The original manufacturers shipping description is normally sufficient for preparation of the TtEMI shipping paper. Shipping papers identify the source isotope(s), form, activity, weight, and other relevant information such as United Nations (UN) classification.

2.7 PACKAGE LABELING

Transport packages shall be labeled as if for common carrier transport. The original manufacturers labeling description is normally sufficient for preparation of the TtEMI label. Labels must be purchased to conform to the DOT labeling specifications. Certain exempted articles may only require an inner package labeling.

2.8 TRAINING OF TRANSPORTATION PERSONNEL

Authorized users shall complete DOT training as specified in 49 CFR before transporting licensed radiation sources that are subject to DOT regulation. Sources with specific activity below 2,000 picocuries per gram are generally exempt from DOT regulation. The RSO may authorize limited use for authorized users who are not required to transport sources on public roads, which are subject to DOT regulation.

2.9 EMERGENCY ACTIONS

All personnel authorized to use licensed radioactive sources shall be trained in proper emergency response actions in the event of (1) loss or theft; (2) leakage, gross physical damage, or fire; or (3) automobile accident or incident involving the public. The following subsections contain specific actions.

2.9.1 ACTIONS IN EVENT OF LOSS OR THEFT OF SOURCE

Take the following action for lost or stolen source:

- Notify the RSO who will notify the RHB.
- Attempt to identify location where source was last seen.
- Inform local authorities (police or base security) that lost or stolen object contained radioactive material and provide RSO point of contact for technical information

2.9.2 ACTIONS IN EVENT OF LEAKAGE, GROSS PHYSICAL DAMAGE, OR FIRE INVOLVING SOURCE

Take the following action for damaged or leaking source:

- Notify the RSO, who will notify the RHB.
- Attempt to isolate source and minimize dispersion of radioactive material.
- Inform fire authorities that source containing radioactive material is involved and provide RSO point of contact for technical information

2.9.3 ACTIONS IN EVENT OF AUTOMOBILE ACCIDENT OR INCIDENT INVOLVING THE PUBLIC

Take the following action for accident or incident involving the public source:

- Notify the RSO, who will notify the RHB.
- Identify the location of the source and provide local authorities with the shipping papers.
- Inform local authorities of the involvement of radioactive material and provide RSO point of contact for technical information

2.10 NOTIFICATIONS

Notification of the RSO is required for any of the previously described emergency situations. The RSO will determine reportability to RHB and other authorities.

N00236.001572
ALAMEDA POINT
SSIC NO. 5090.3

APPENDIX A
STANDARD OPERATING PROCEDURES

FIELD INSTRUMENT CALIBRATION AND OPERATIONAL CHECKS

FINAL
STATUS RADIATION SURVEY AND FIELD SAMPLING PLAN

THE ABOVE IDENTIFIED SECTION IS NOT AVAILABLE.

EXTENSIVE RESEARCH WAS PERFORMED BY NAVFAC SOUTHWEST TO LOCATE THIS SECTION. THIS PAGE HAS BEEN INSERTED AS A PLACEHOLDER AND WILL BE REPLACED SHOULD THE MISSING ITEM BE LOCATED.

QUESTIONS MAY BE DIRECTED TO:

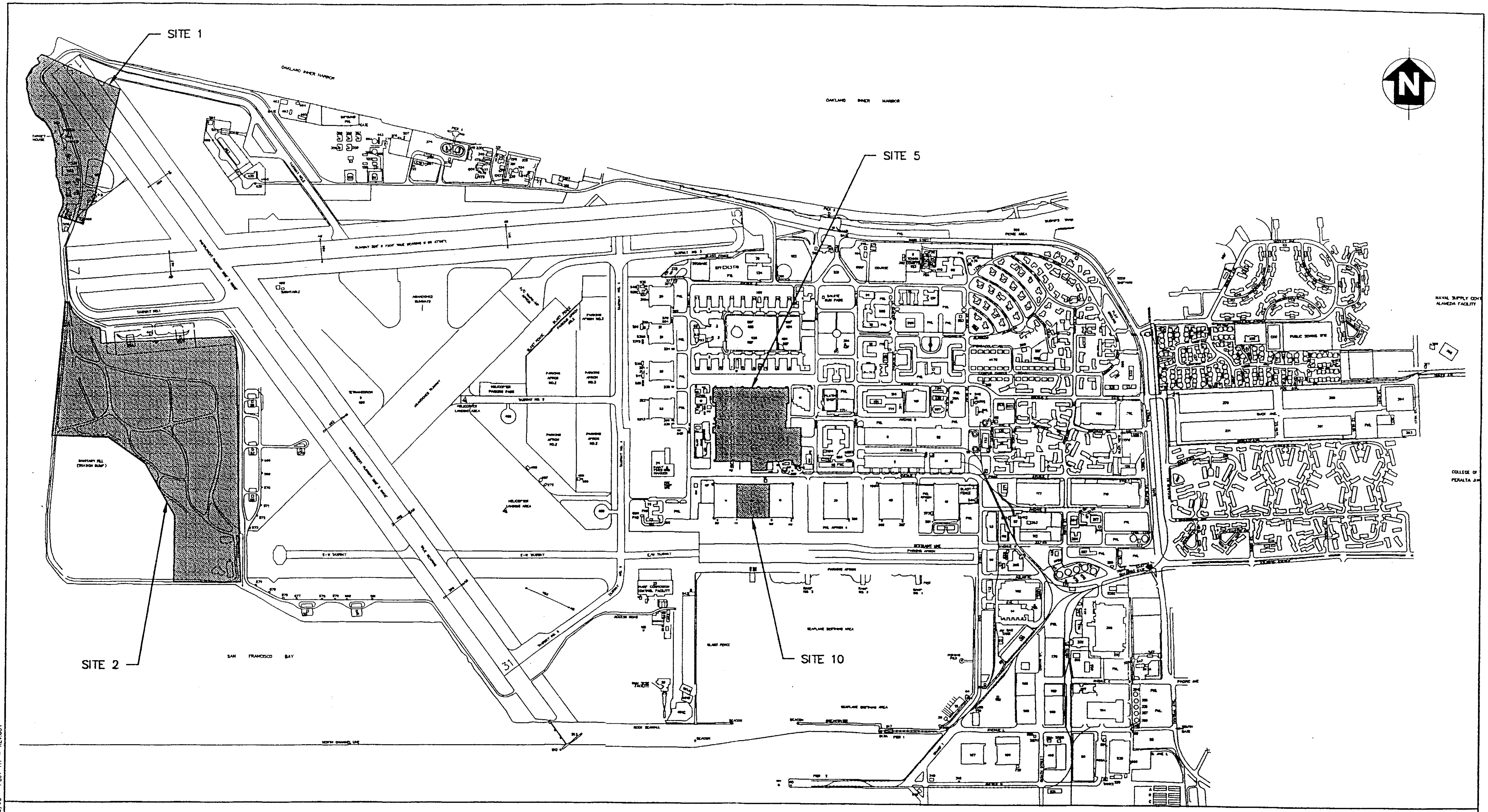
DIANE C. SILVA
RECORDS MANAGEMENT SPECIALIST
NAVAL FACILITIES ENGINEERING COMMAND SOUTHWEST
1220 PACIFIC HIGHWAY
SAN DIEGO, CA 92132

TELEPHONE: (619) 532-3676

APPENDIX B

SITE FIGURES

FIGURES IN APPENDIX B



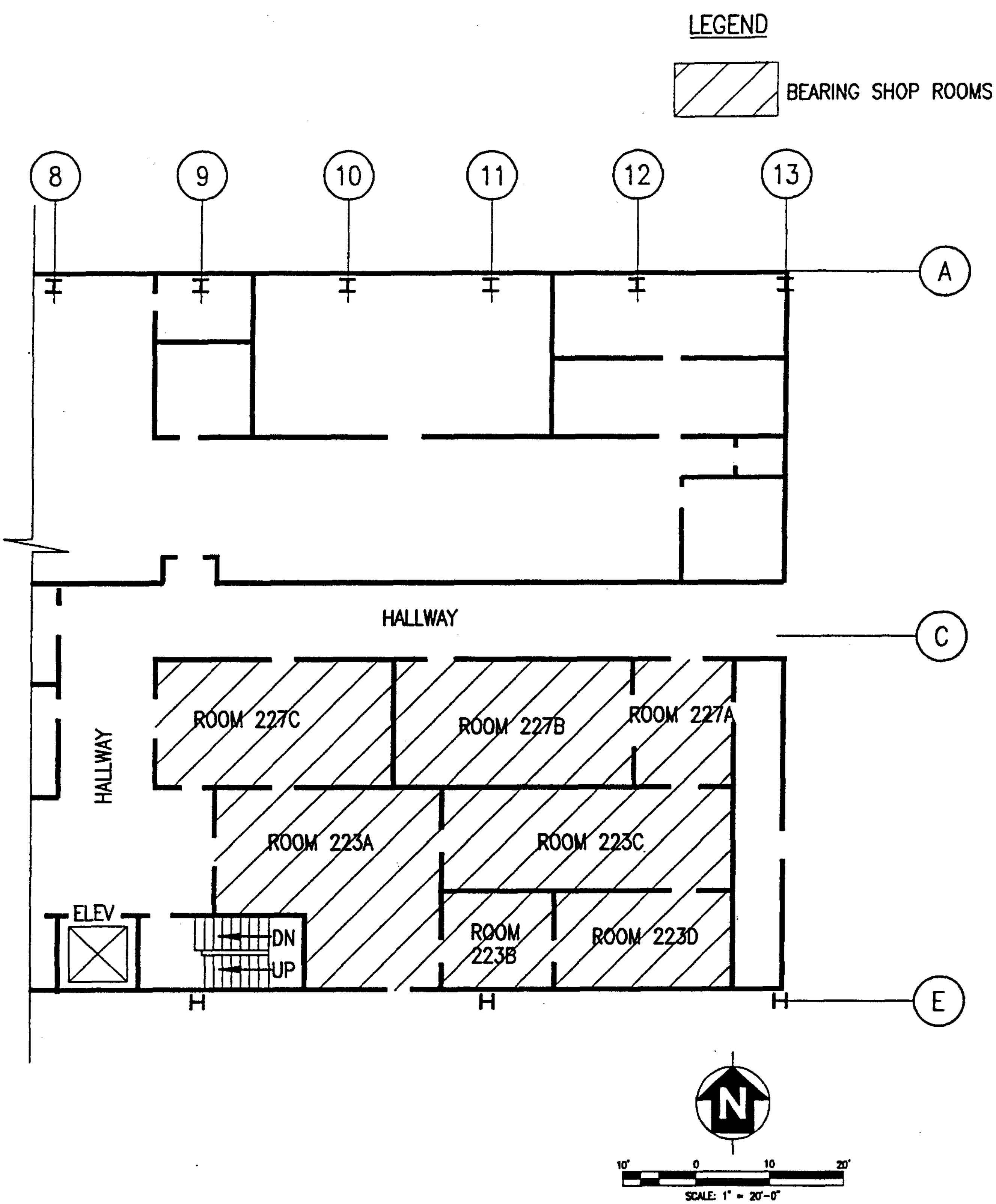
SOURCE: "RADIATION SURVEY REPORT, NAVAL AIR STATION, ALAMEDA, CALIFORNIA", PRE-DRAFT FEBRUARY 1997

NAS ALAMEDA, CALIFORNIA

Figure 1
LOCATION OF SITES
1, 2, 5 AND 10

ENGINEERING FIELD ACTIVITY WEST

KCH (SF) (059-147) NASBSIZE.DWG 03/03/98 - PLOT 1:1 - REV.001



ALAMEDA POINT, ALAMEDA, CALIFORNIA

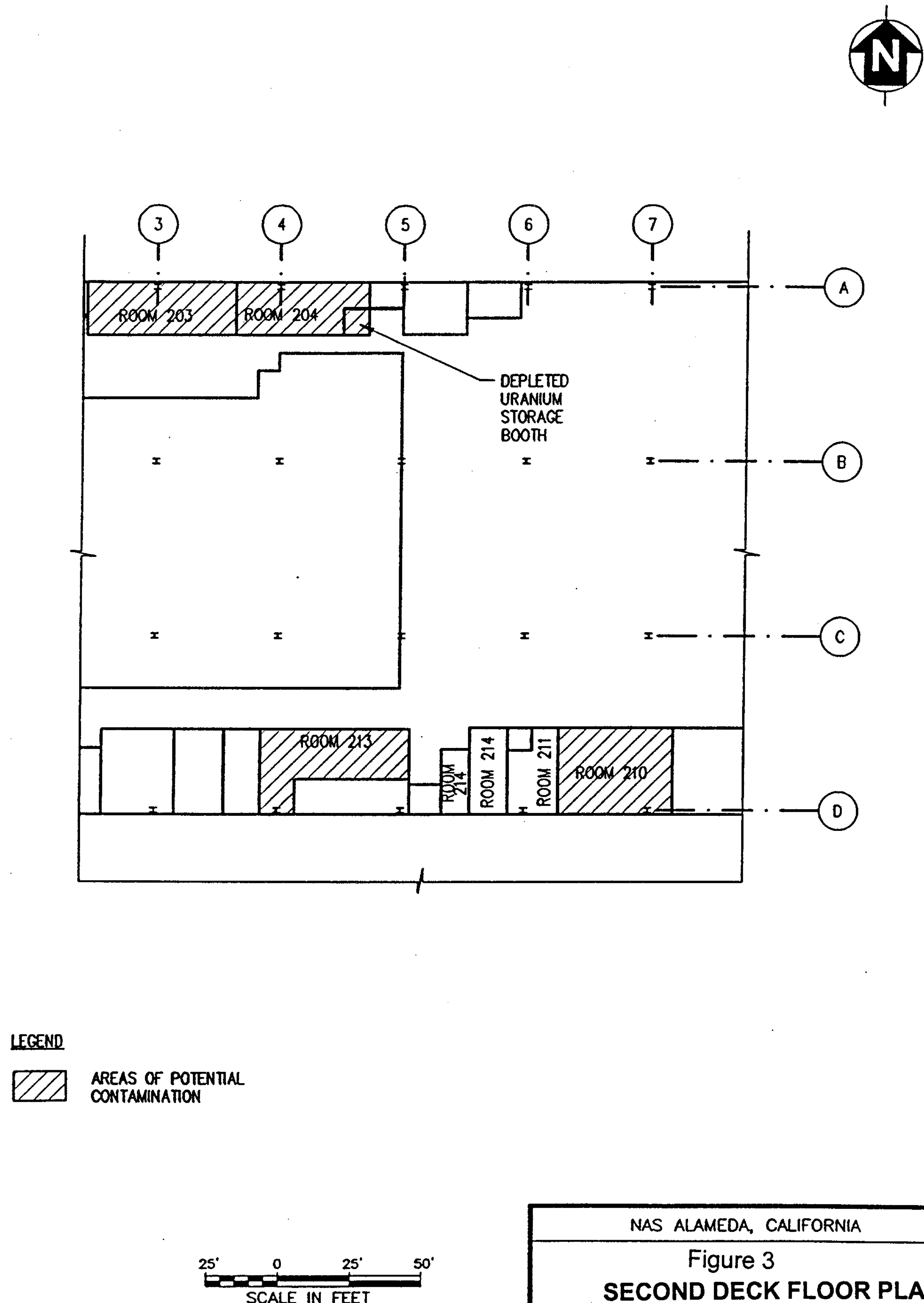
Figure 2

SECOND FLOOR PLAN, BUILDING 5

PROJECT NO.:	ORGINATOR:	CHECKER:	DATE:
4545-0147	ALM	KN	11/97

DATE: 11/05/97

FILENAME: \ALA_RAD/DWG/0147_2-5.DWG



NAS ALAMEDA, CALIFORNIA

Figure 3

SECOND DECK FLOOR PLAN

BUILDING 400

ENGINEERING FIELD ACTIVITY WEST

KCH (SF) (069-147) 147211.DWG 04/30/98 PLOT 1:1 REV.001

Figure 4

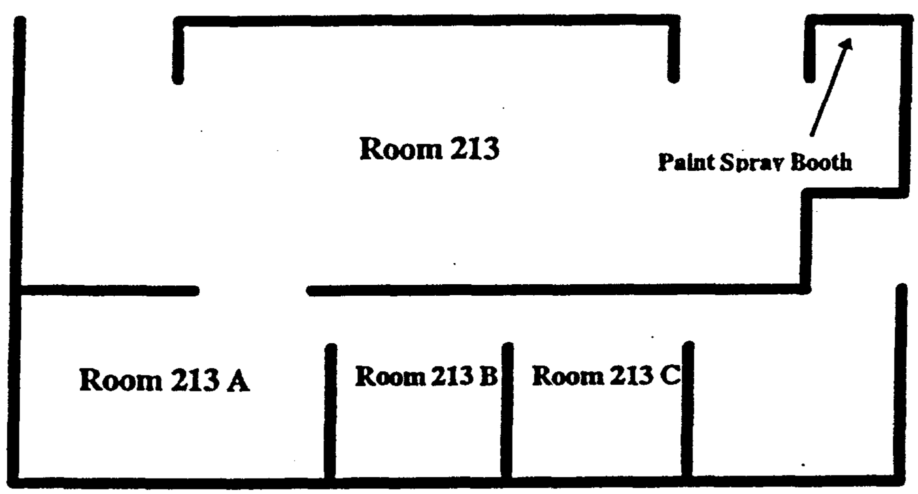
DRAIN LINE DIAGRAMS, BUILDING 400

(multiple sheets)

Building 400, Second Deck, Room 213

Room 213 of building 400 is currently subdivided into five rooms (see figure 400.1). One large room that contains the paint spray booth line and four smaller rooms, 213A, 213B, 213C and 213D. A paint spray booth was located in the North East corner of the largest room, approximately four feet of exposed pipe of interest is present. Along the south length of room 213 there are four smaller rooms, 213A, 213B, 213C and 213D. Only rooms A, B and C contain drain lines of interest. Rooms A, B and C contain approximately 28 feet of exposed pipe which drains into the south roof down comer.

Figure 400.1. NADEP Alameda, Building 400, Second Deck, Room 213



A gamma radiation survey was performed using a 2"x 2" NaI detector for external surfaces and a 1" x 1" NaI detector for the survey of the interior of the paint spray booth line.

Background Determination

Background counting data was gathered by selecting a geometrically similar area in room 213D away from the areas of interest. The background for each survey is recorded on the individual Radiation Survey Report forms.

Paint Spray Booth, Room 213

The paint spray booth line has approximately four feet of exposed pipe before it enters the floor of the second deck. The pipe emerges from the ceiling of the first deck and runs approximately 45 feet before emptying into a main overhead drain line on the south side of the first deck. The main overhead drain emerges from room 138 and travels across to the north side of the building where it is intersected by lines from other areas of interest. This expanse is approximately 130 feet.

Interior Survey

The interior survey of the paint spray booth was limited due to blockage by materials present in the pipe would not allow the passage of the probe. The initial interior survey entered at point A in the drawing and proceeded along points A1, A2, A3 and A4. No activity above measured background was found in the interior survey (see figure 400.3).

We were unable to complete an interior survey of the paint spray booth drain line accessed for the first deck overhead area. The pipe which is two inches ID was completely blocked after a little over one foot of travel.

Exterior Survey

The exterior survey of the pipe includes the exposed pipe in the 213 paint spray booth to where it enters the second deck floor then continues in the overhead of the first deck. While surveying the exposed piping a single high spot was identified at survey point #29 (see figure 400.4 and 400.5). An internal survey of the pipe was attempted from the clean-out at point B, but the passage is clogged with a rust colored material that has a strong organic smell. The survey results are attached.

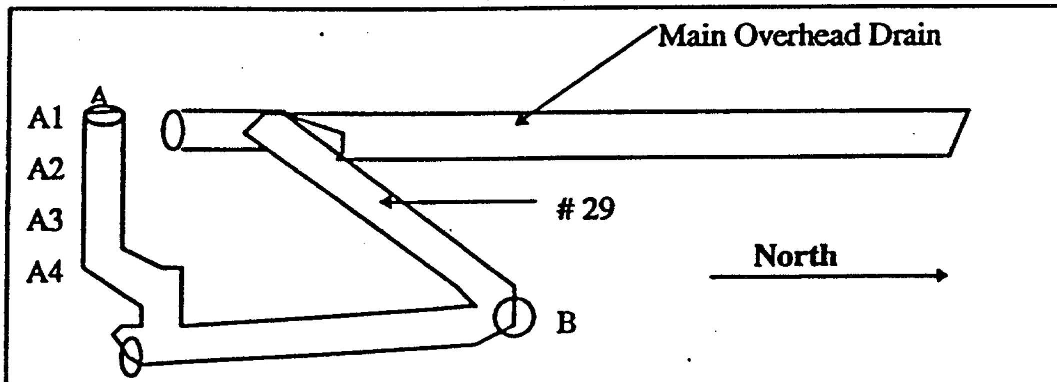


Fig. 400.2. Paint Spray Booth Drain Line to Main Overhead Drain

Background

Determination of background for the pipes in the overhead spaces of the first deck is essentially a moving target. The main sources of background radiation are the concrete floors, walls and ceilings. As the detector changes position in space its geometric relation to these sources changes but the change cannot be steady due to a labyrinth of pipes in the overhead space which randomly act as changing shields as you move along each pipe.

Background measurements were taken in similar places in the overhead spaces away from the drain lines of interest. The result is recorded on the Radiological Survey Report.

Figure 400.3 Bldg. 400, Room 213 Paint Spray Booth Interior Drain Line Survey, Radiological Survey Report (RSR) #1

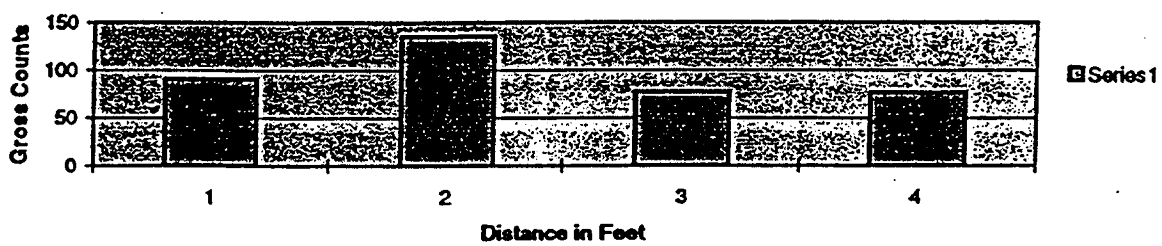


Figure 400.4. Exterior Survey of Pipeline From Paint Spray Booth in Room 213, RSR # 2.

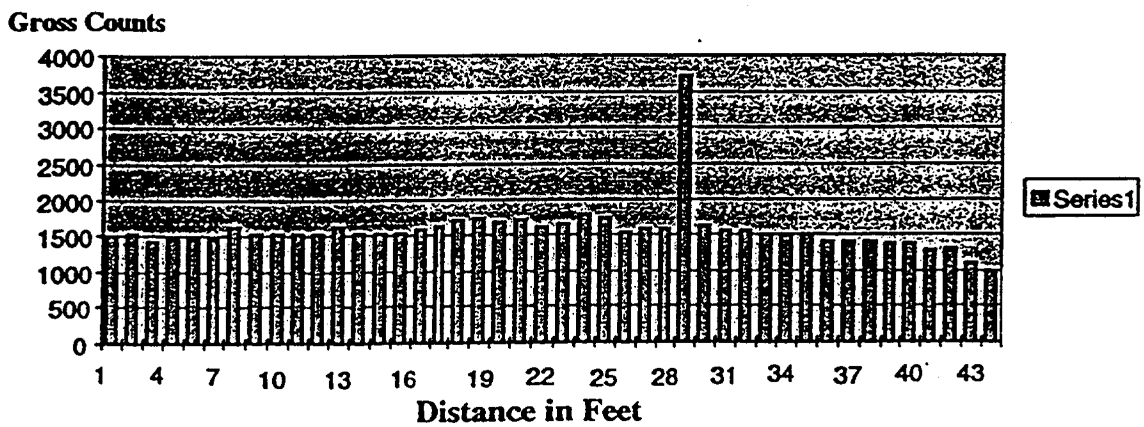
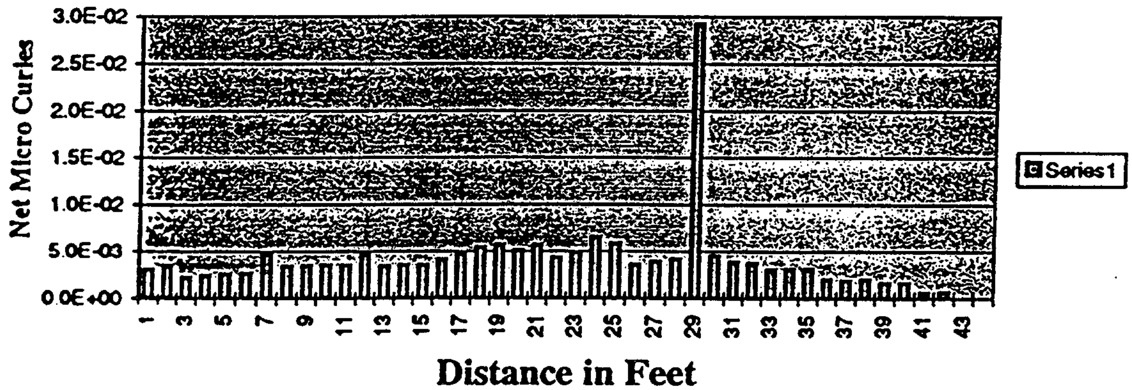


Figure 400.5. Exterior Survey of Pipeline From Paint Spray Booth in Room 213, RSR #2.



Building 400, Room 213 A, B and C

Along the south wall of 213A, 213B and 213C is a pipe that penetrates the floor of the second deck in room 213A and empties into the down comer from the roof. NWT personnel surveyed the exterior of the pipe from the beginning of the drain in room 213C to the point where the down comer enters the concrete slab in the first deck in the south wall of room 138. The counting results are attached.

The determination of background in this area was difficult. It is higher here than most other areas which may be due to the intersection of walls and floors and their content. In examining the results it does not appear that there was any significant activity above normal background. But this may be difficult to establish without a examination of the gamma spectrum.

Fig. 400.6. **Room 213 A, B and C, External Radiation Survey**

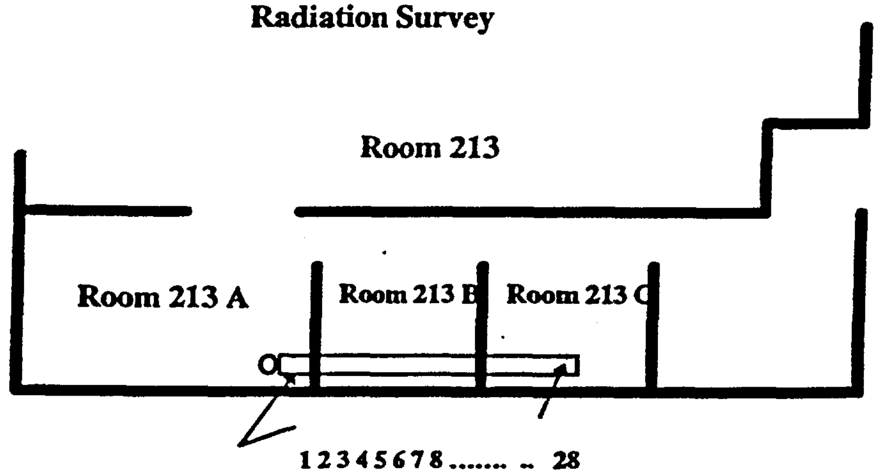


Figure 400.7. External Survey of Pipe in Rooms 213 A, B and C, RSR # 3.

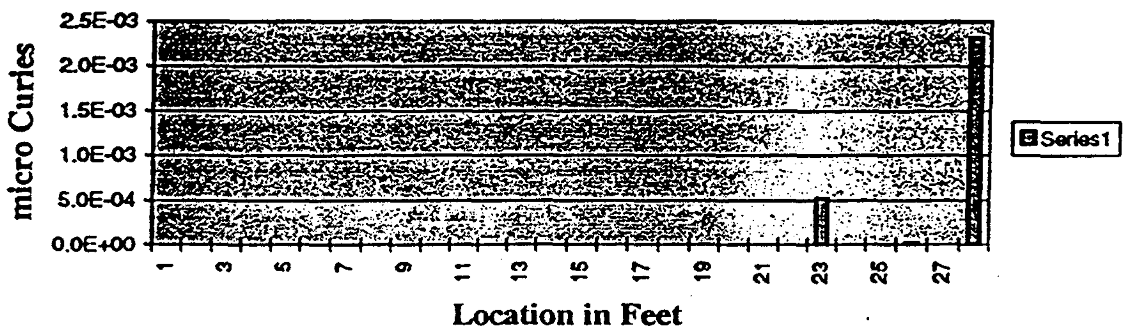
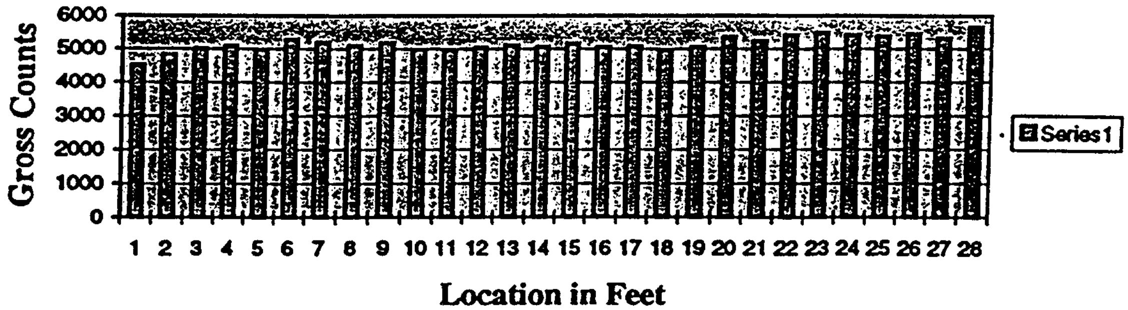


Figure 400.8. External Survey of Pipe in Rooms 213 A, B and C, RSR # 3.



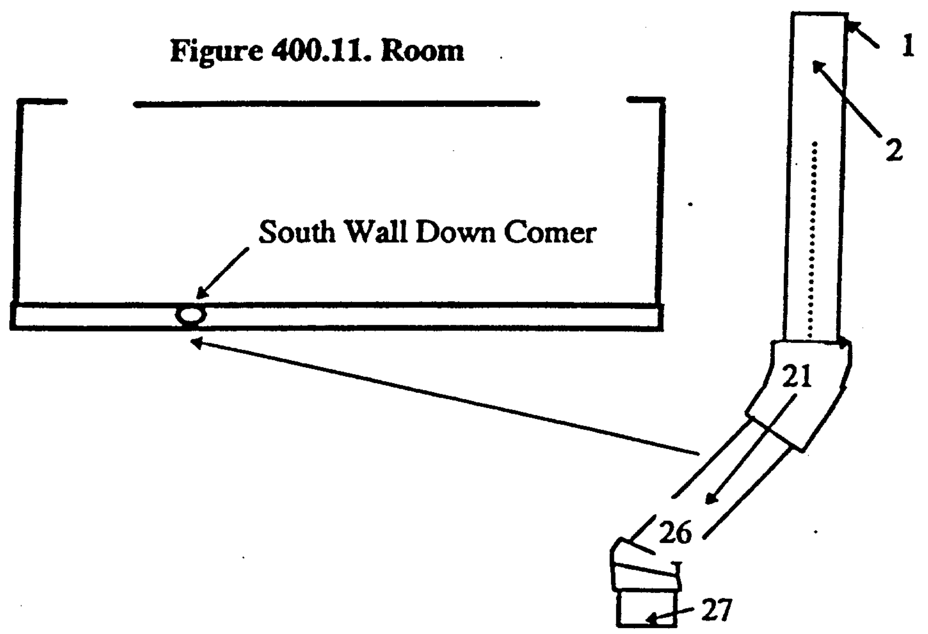
South Wall Down Comer

The drain line from rooms 213 A, B and C empty into the down comer from the roof of building 400. Access to the down comer is through the ceiling and wall of the south side of room 138 on the first deck of building 400.

This drain was surveyed from the ceiling of room 138 on the first deck to the point where it enters the concrete floor

This down comer is joined into by the main overhead drain that travels from the south wall of room 138 to the north wall of room 112 on the north side of building 400.

Figure 400.11. Room



The survey results for the down comer shows one area that is greater than three times background. Measurement 22 is 4.9 times background. This may be due to contamination inside the pipe or a change in the concrete wall that the pipe is against. It would make sense that this point in the pipe where it goes from vertical to an angle would be where any radioactive material from the upper floor may have become fixed. Without a spectrum analysis it would be difficult to judge the source. It may be useful to repeat certain measurements near walls like this with lead sheets blocking the radiation from the adjacent walls.

Figure 400.9. Survey of South Wall Down Comer in Room 138, RSR #4

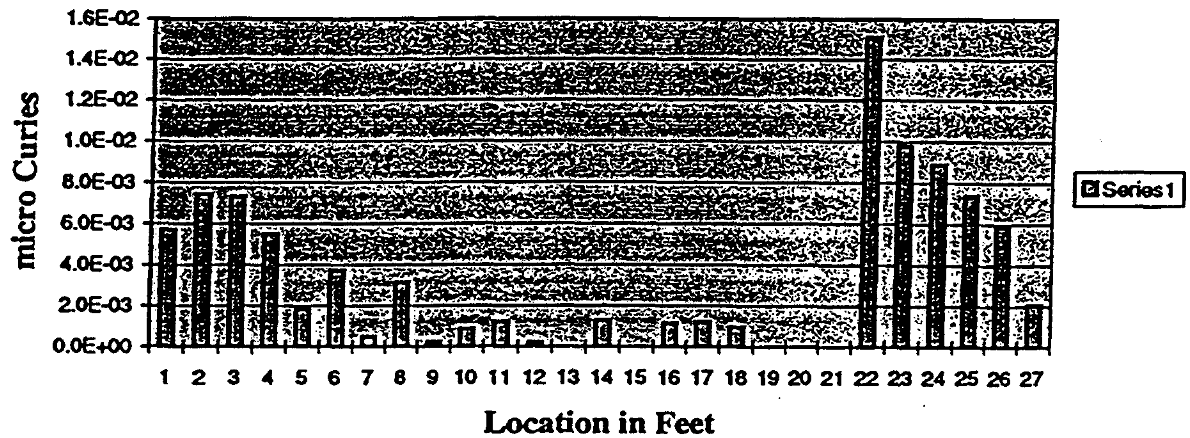
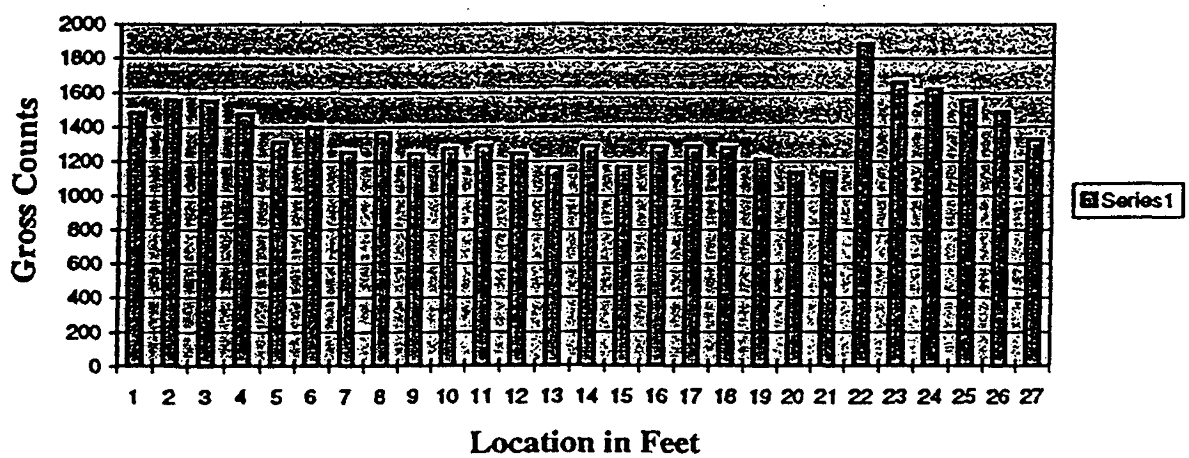


Figure 400.10. Survey of South Wall Down Comer in Room 138, RR #4



Main Overhead Drain

Beginning from the south wall down comer of building 400 in room 138 a four inch ID drain reaches through the overhead space through the north wall of room 138 across the entire first deck to the north wall in room 112. The drain line empties into a down comer which leaves the building and eventually empties into the sanitary sewer. This drain line is intercepted by several drain lines of interest. This line was surveyed in three sections, room 138, main room, room 112.

Background

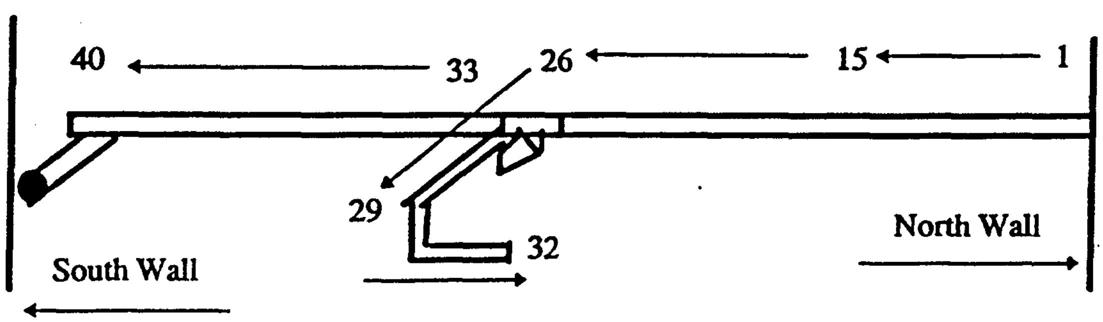
Determination of background for the pipes in the overhead spaces of the first deck is essentially a moving target. The main sources of background radiation are the concrete floors, walls and ceilings. As the detector changes position in space its geometric relation to these sources changes but the change cannot be steady due to a labyrinth of pipes in the overhead space which randomly act as changing shields as you move along each pipe.

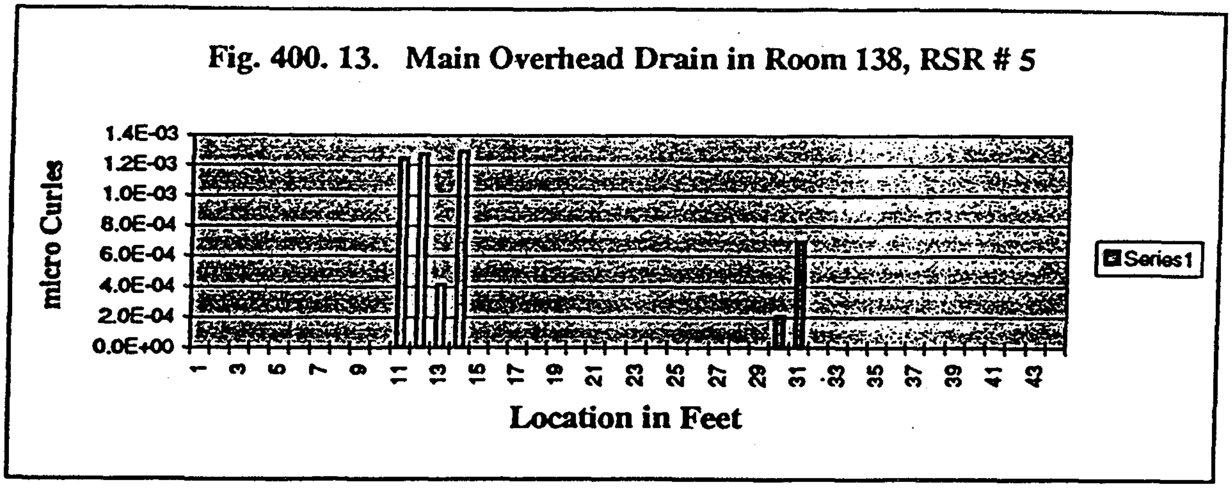
Background measurements were taken in similar places in the overhead spaces away from the drain lines of interest. The result is recorded on the Radiological Survey Report.

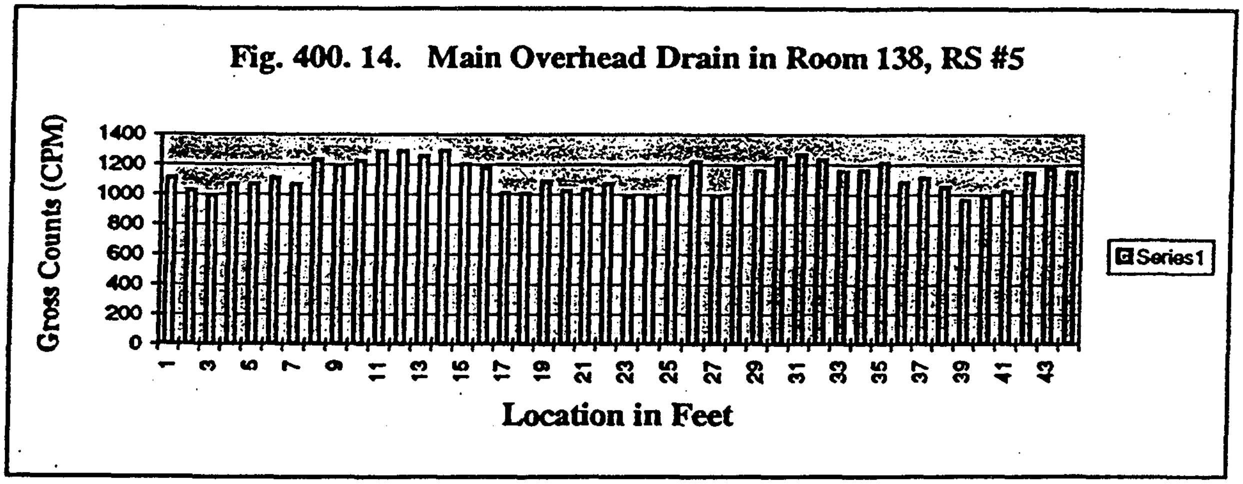
.oom 138 Main Overhead Drain

The room 138 main overhead drain spans a length of approximately 42 feet. There did not appear to be any contamination present from examining the counting results.

Fig. 400.12. Main Overhead Drain in Room 138.



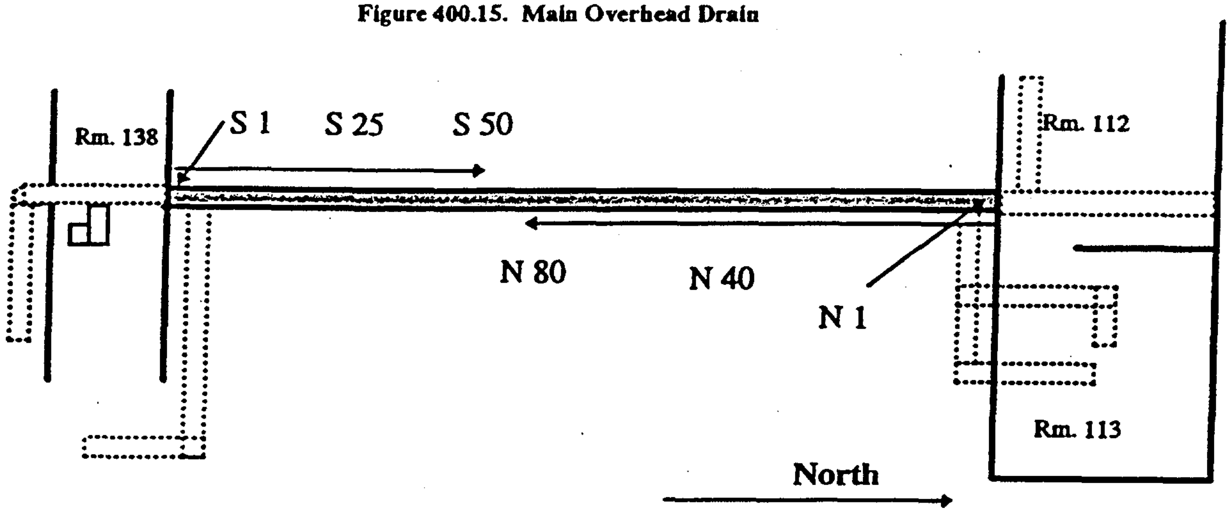




Main Room Main Overhead Drain

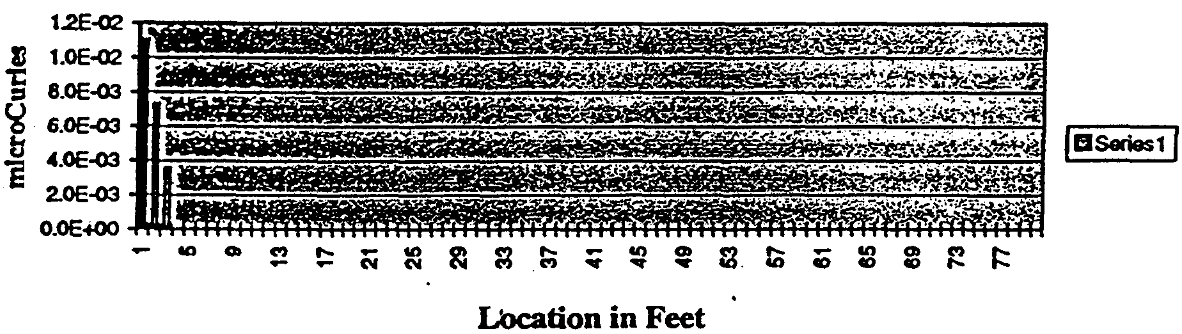
The main overhead drain was surveyed by two teams working from the north and south sides of the building simultaneously toward the center of the main room. Except for on the north end where the line is intercepted by a contaminated line there does not appear to be any contamination present within detectable limits.

Figure 400.15. Main Overhead Drain



The results of the survey outside of room 112 for the first 80 feet to the south are displayed in figure 400.16. The survey results outside room 138 for the first 50 feet to the center of the room are displayed figure 400.18 and 400.19.

Figure 400. 16. Exterior Survey of Main Overhead Drain 80 feet from Room 112 Towards Room 138, RSR # 6.



As stated earlier the bar graph indicates no contamination within the limits of detection except where the pipe connects to the drain from the old DU room and room 204 areas on the second floor. It is not possible to tell if the elevated activity is from contamination in the main or from the intersecting pipe which does contain radioactive material.

Figure 400. 17. Exterior Survey of Main Overhead Drain 80 feet from Room 112 Towards Room 138, RSR # 6.

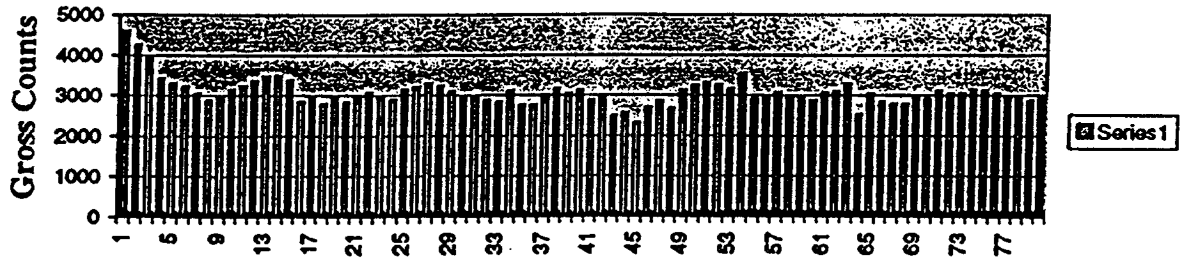


Figure 400.18. Exterior Survey of Main Overhead Drain from Outside Room 138 for 50 feet North Towards Room 112, RSR # 7.

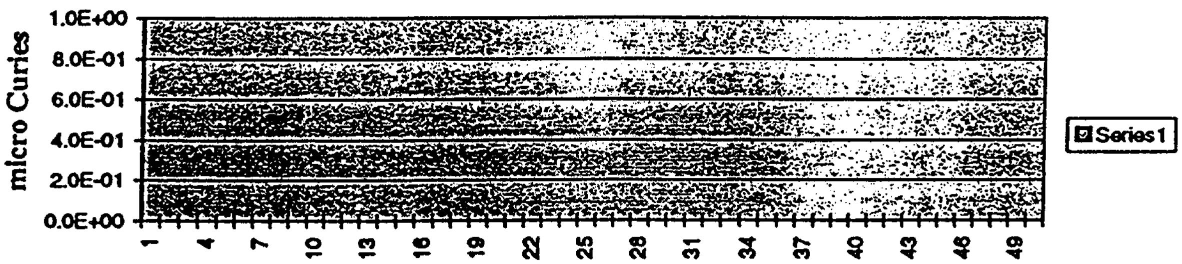
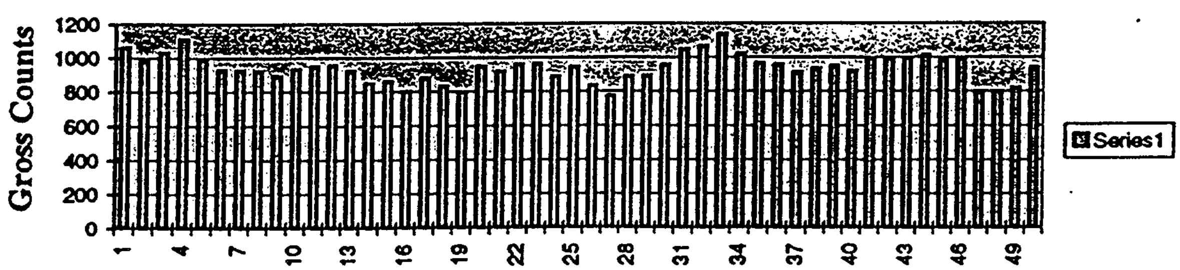


Figure 400.19. Exterior Survey of Main Overhead Drain from Outside Room 138 for 50 feet North Towards Room 112, RSR # 7.



Drain Lines From Rooms 204, 203 and Storage Room For Depleted Uranium.

On the second deck of building 400 there were three additional areas of interest. These were the drain lines that once connected to the depleted uranium store room. Two drains that lead from room 204 all of which penetrate the second deck into room 113 below. There was also one line that penetrates the floor in room 203 into room 112 below. All of these drain lines empty into the main overhead drain before it exits the building.

Storage Room For Depleted Uranium

From the second deck room labeled as depleted uranium storage there appears to have been two drain lines. One just inside the room and one just outside the room. The two inch ID pipe inside the room has been removed and only the hole remains (please note this drawing is not to scale). Although the line that runs through the overhead of room 113 is in place.

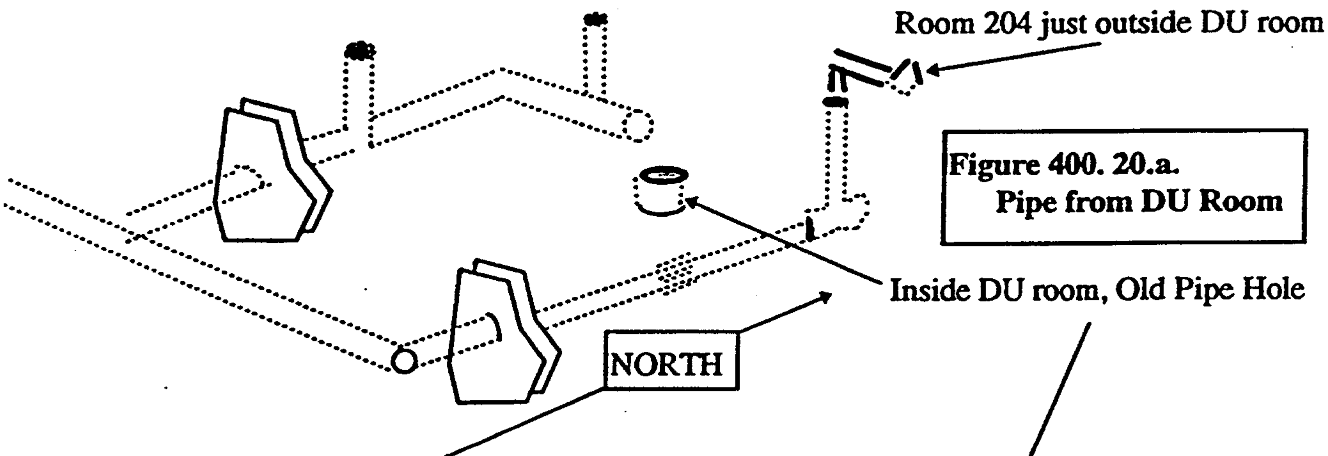
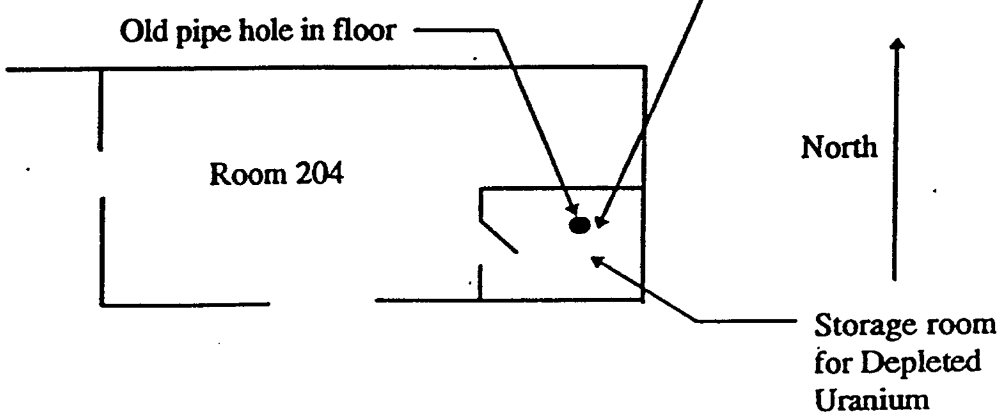
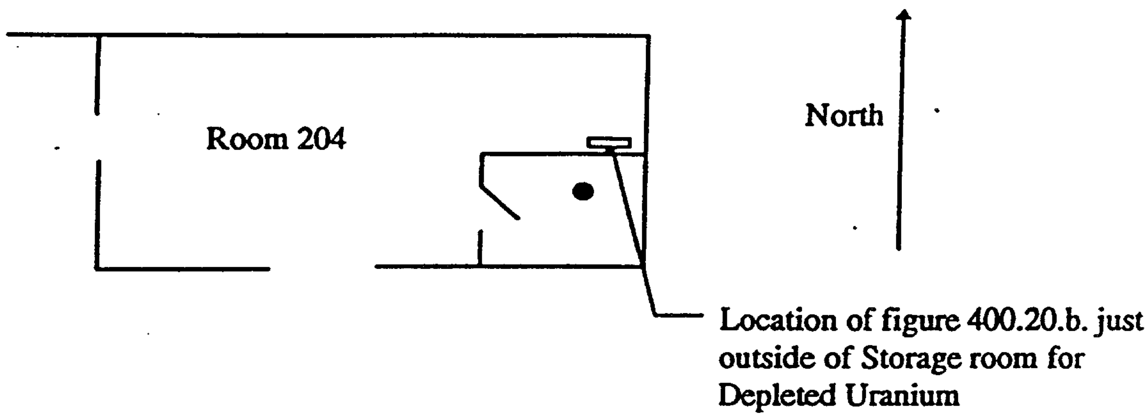


Figure 400. 20.a.
Pipe from DU Room

The second deck floor plan (attached) shows Room 204 with a smaller room indicated as the storage room for depleted uranium.





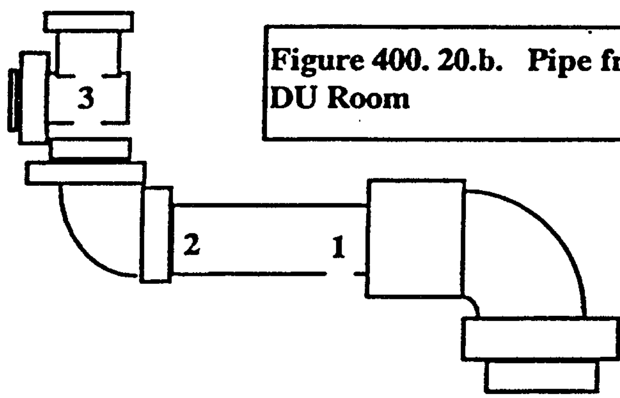


Figure 400. 20.b. Pipe from DU Room

The survey results for this section of pipe are attached (see figures 400.21 and 400.22). The determination of background in this small area is difficult because of the intersection of the concrete walls and floor in the corner. Slight changes in location can make large differences in the background. I does not appear that there is any activity above background based on measurements in other areas with similar geometry.

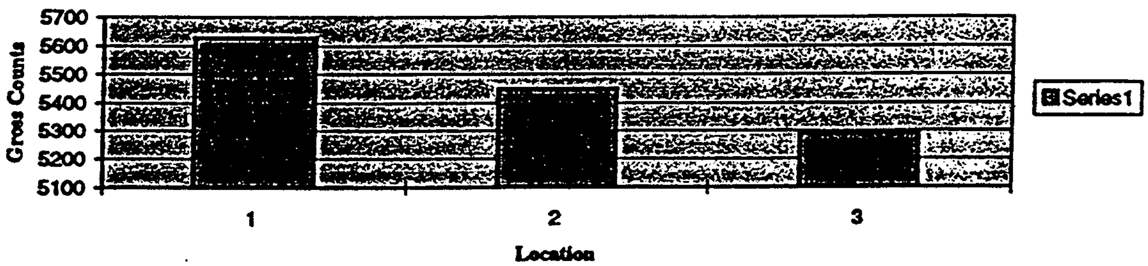


Figure 400. 21. Pipe Outside of North Wall of DU Room, SR # 8.

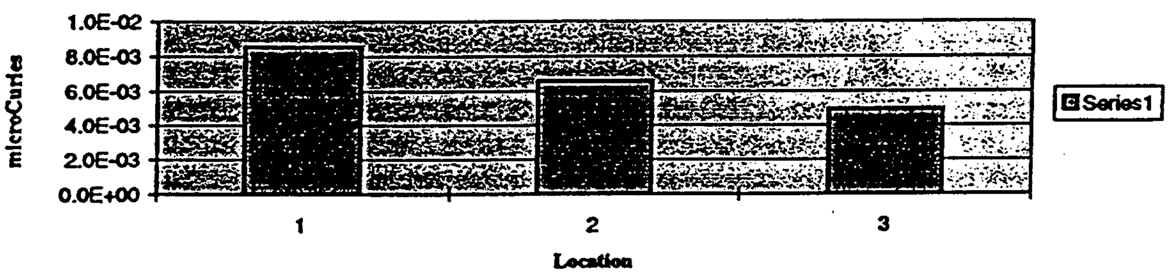


Figure 400. 22. Pipe Outside of North Wall of DU Room, RSR # 8.

Eye Wash Station Room 204

Just to the right of the entry to room 204 is a eye wash station atop an older drain.

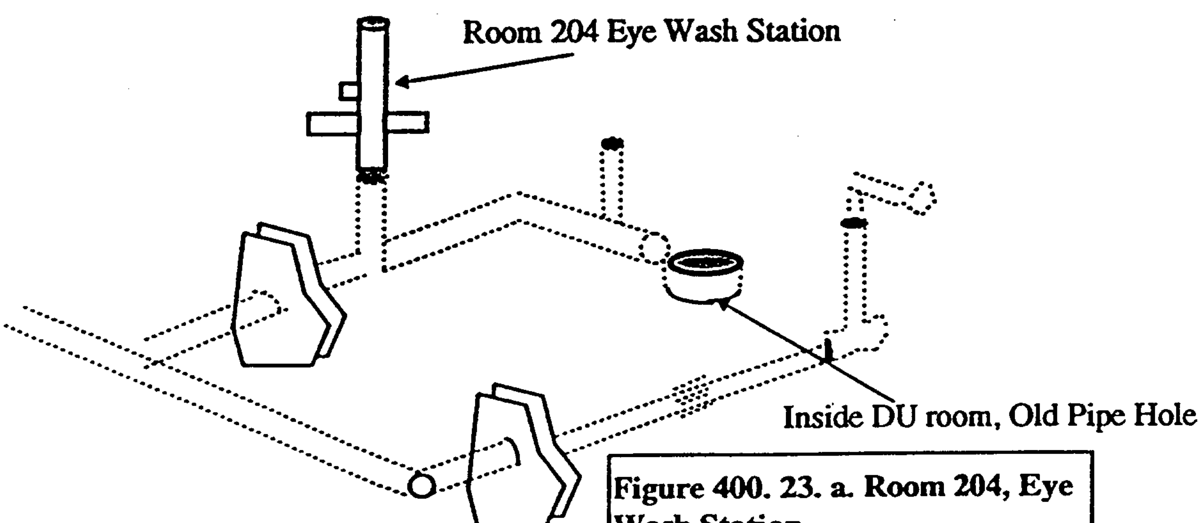


Figure 400. 23. a. Room 204, Eye Wash Station

The exterior north side of the pipe was surveyed from the floor to the top as indicated in figure 400. 23.b. The pipe is approximately 2.5 inch OD.

Figure 400. 23. b. Room 204, Eye Wash Station

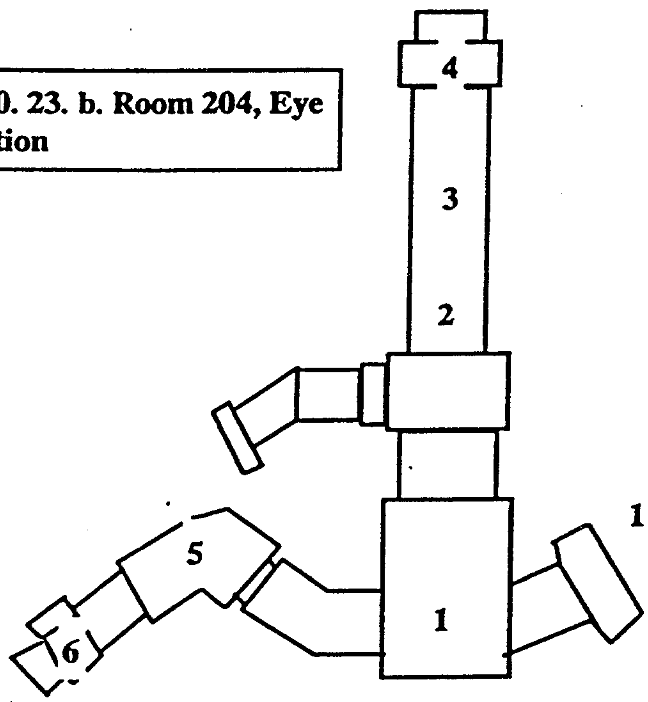


Figure 400. 24. Room 204 Eye Wash Station Drain, RSR # 9.

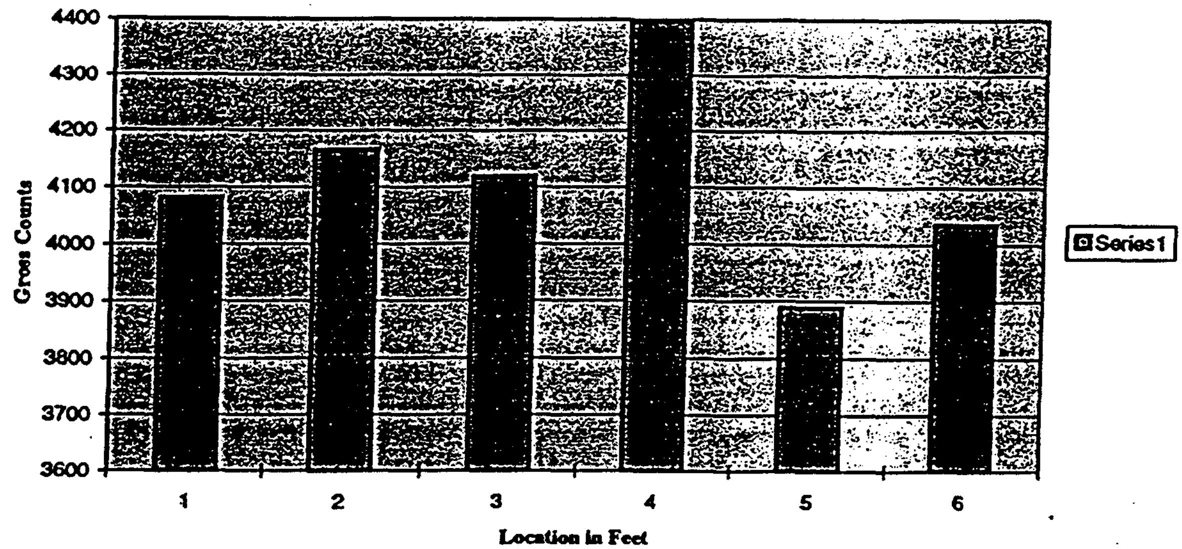
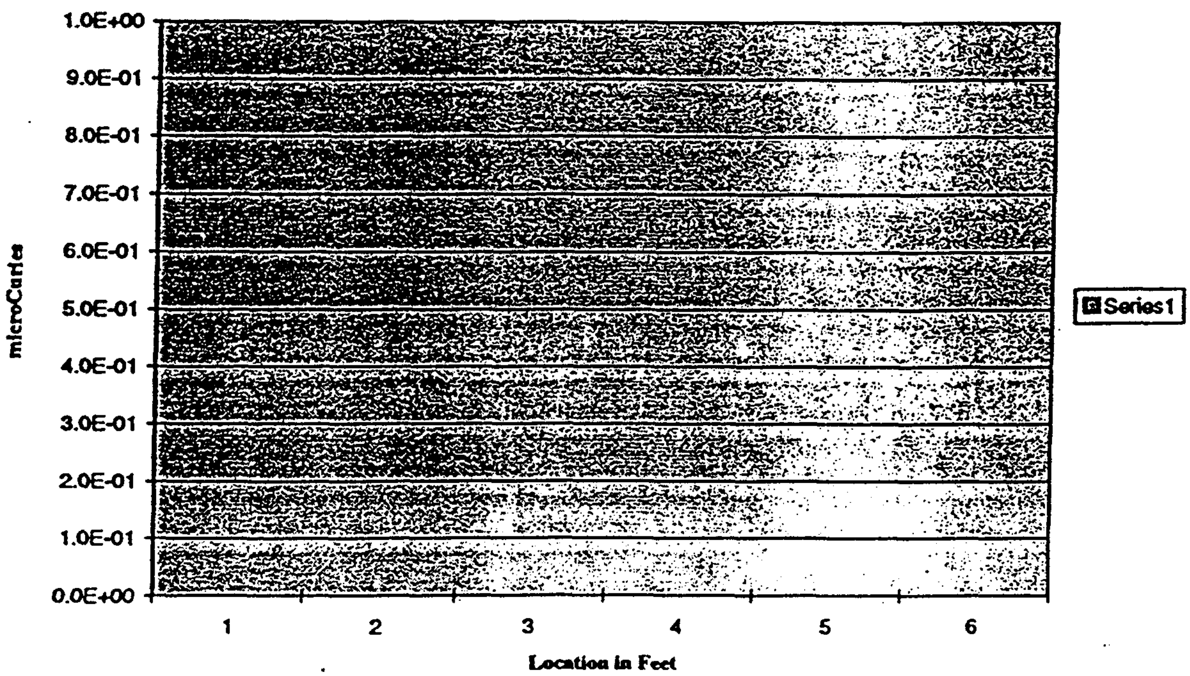


Figure 400. 25. Room 204 Eye Wash Station Drain, RSR # 9.



Room 204 Capped Pipe in Floor

Across room 204 to the north east of the eye wash station is a cap on a pipe that penetrates the floor and intersects the same drain line that serves the eye wash station. The pipe only rises an inch or so above the floor surface. An internal survey of this 1.5 inch ID pipe was performed. No activity above background was detected in the first two feet of the pipe. The pipe had significant build-up of materials that prevented further penetration. The survey results are attached.

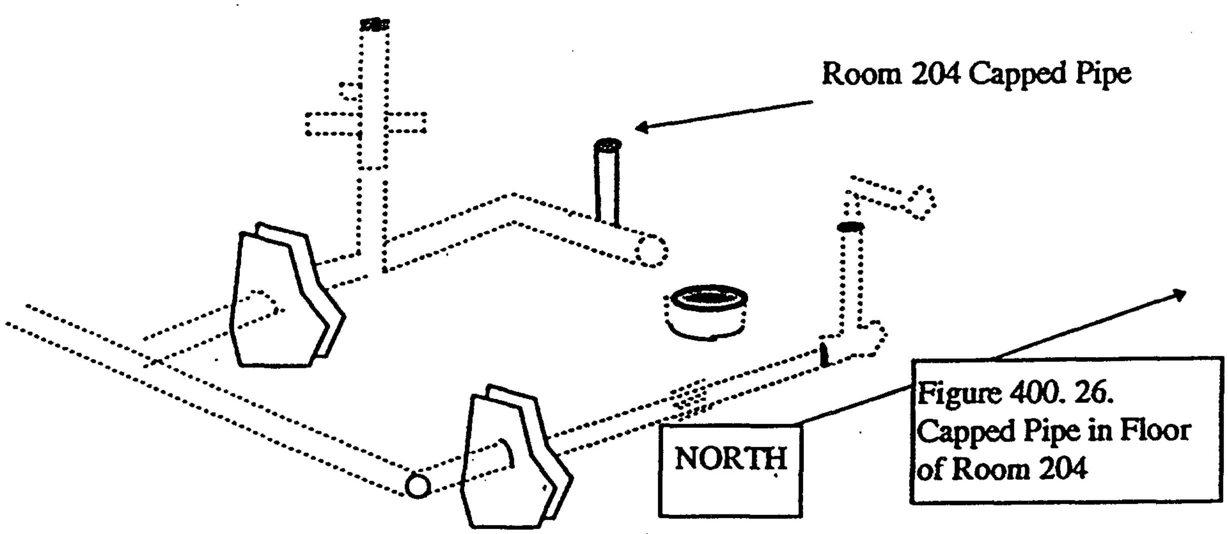
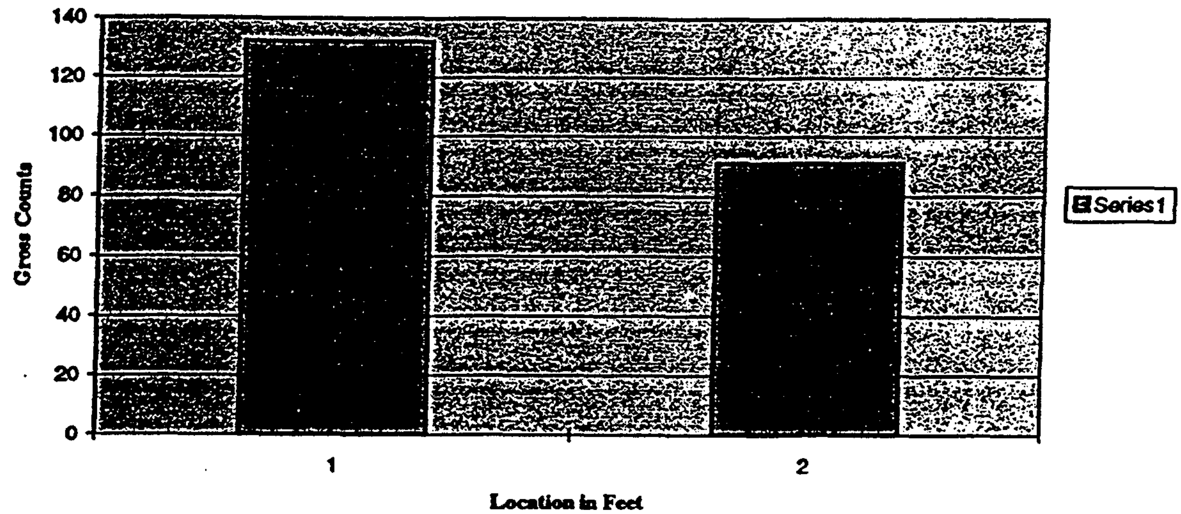


Figure 400. 26. Capped Pipe in Floor of Room 204

Figure 400. 27. Room 204 Interior Survey of Capped Pipe In Floor Across From Eyewash Station, RSR # 10.



Drain Line From DU Room In Overhead of Room 113

In the overhead space of room 113, the first deck of building 400, the drain line from room 204 and the DU room extends approximately 13 feet from the exit from the ceiling to the south wall.

The pipe is two inch ID.

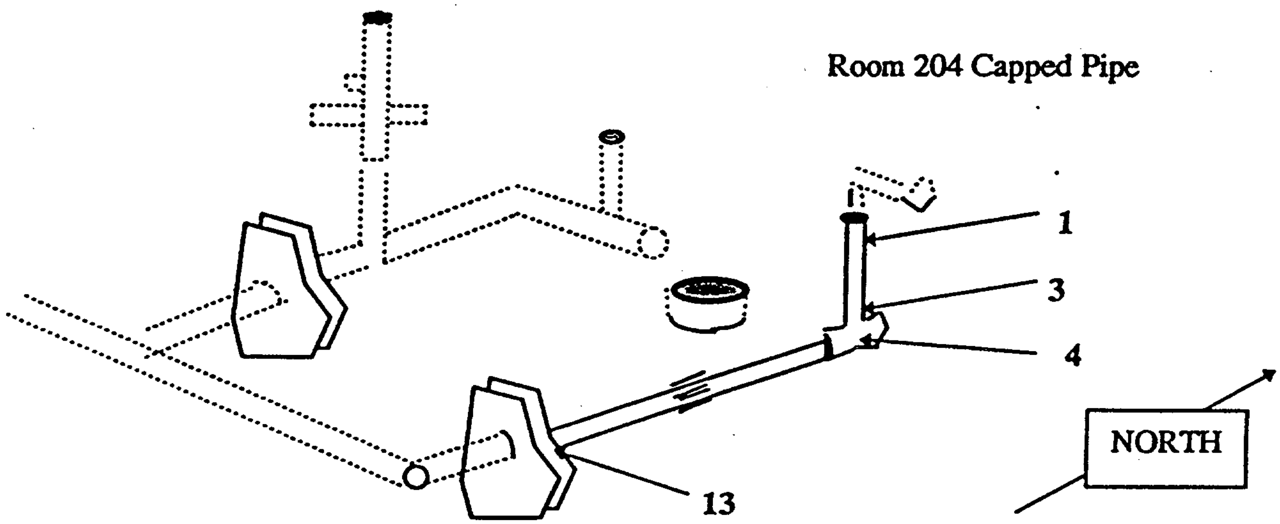


Figure 400. 28. Drain Line From DU Room In Room 113 Overhead Space.

Figure 400. 29. Room 113 Overhead Drain Line From DU Room & Room 204, RSR # 11.

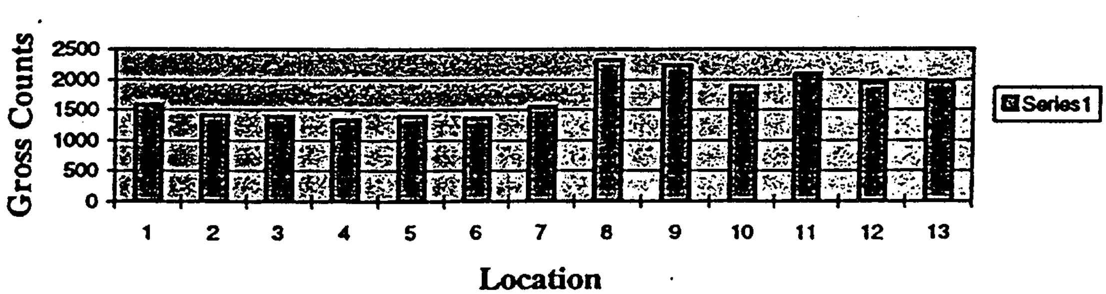
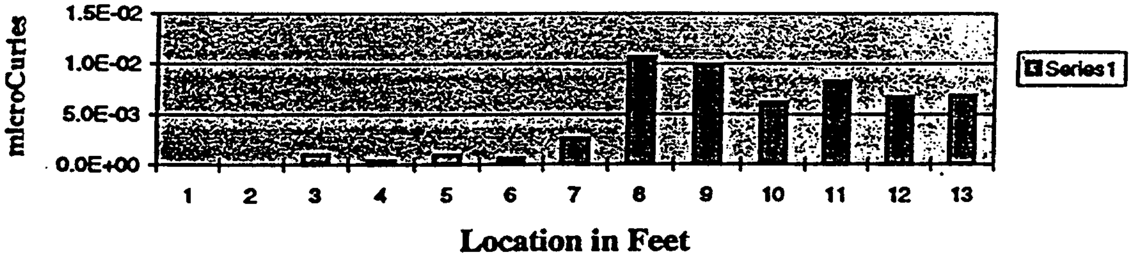


Figure 400. 30. Room 113 Overhead Drain Line From DU Room & Room 204, RSR # 11.



There appears to be some contamination in this pipe particularly as you approach the south wall of this room. The pipe as it exits the wall on the other side is the location of the highest level of contamination.

Room 113 Overhead Piping From Eye Wash Drain To Capped Pipe

The drain lines from room 204 penetrate the second deck and enter the overhead space of room 113.

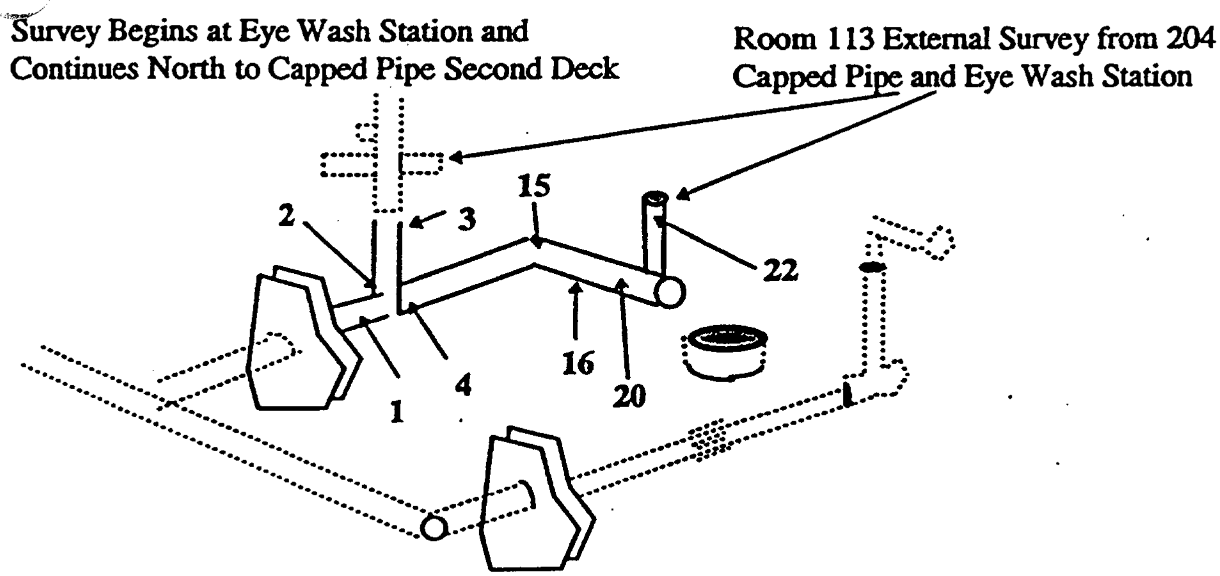


Figure 400. 31. **Drawing of room 113 overhead space survey of exterior drain lines from eye wash station and capped pipe from room 204**

Figure 400. 32. Survey of Exterior Drain Lines in Overhead Space of Room 113 From Eye Wash and Capped Pipe Drain Lines From Room 204, RSR # 12.

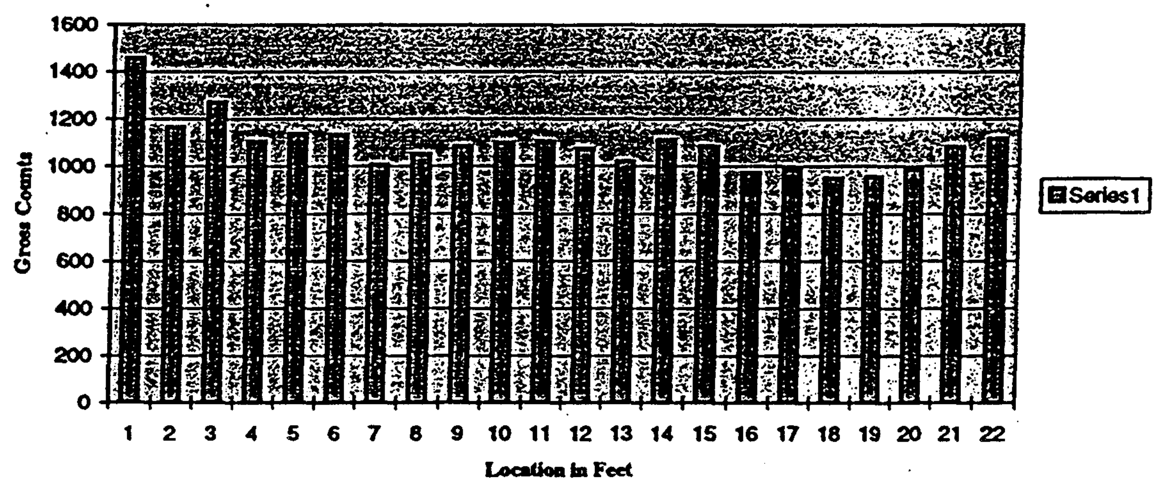
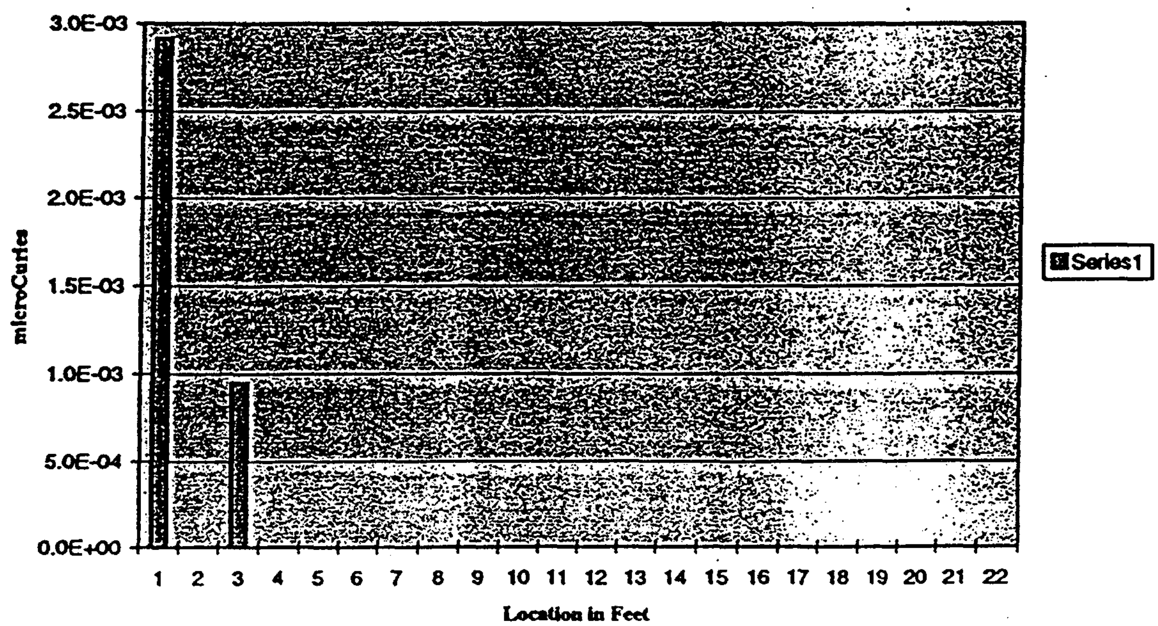


Figure 400. 33. Survey of Exterior Drain Lines in Overhead Space of Room 113 From Eye Wash and Capped Pipe Drain Lines From Room 204, RSR # 12.



Overhead Drain Lines Outside Room 113 From Eye Wash Station & Capped Pipe

The overhead drains extending into room 113 from the second deck penetrate the south wall in two places and empty into a 3.5 inch OD pipe. This pipe continues west for about 34 feet where it intersects the main overhead drain, a 4.5 inch OD line.

Figure 400.34 External survey of overhead drain line outside of room 113 to main overhead drain line. From room 204 and DU room Drain Lines.

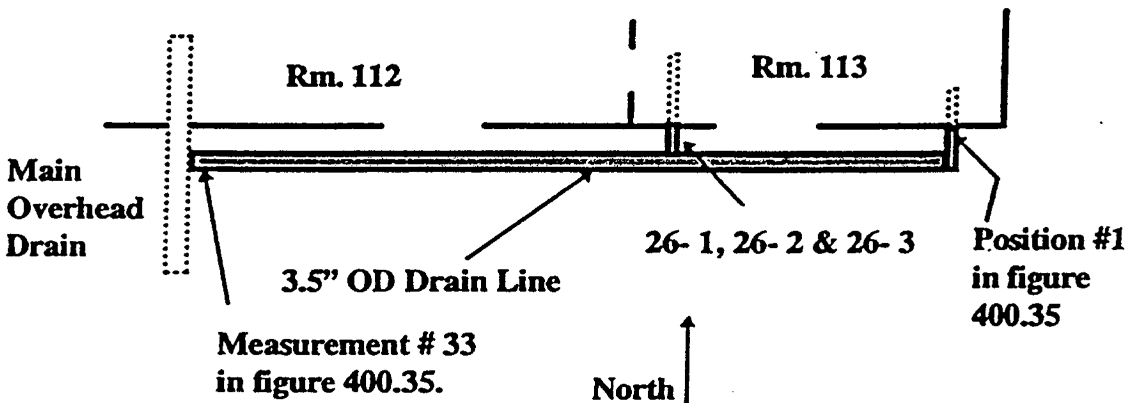


Figure 400. 35. External Survey of Pipe From DU Room and Room 204 Just Outside of Room 112 to Main Overhead Drain, RSR # 13.

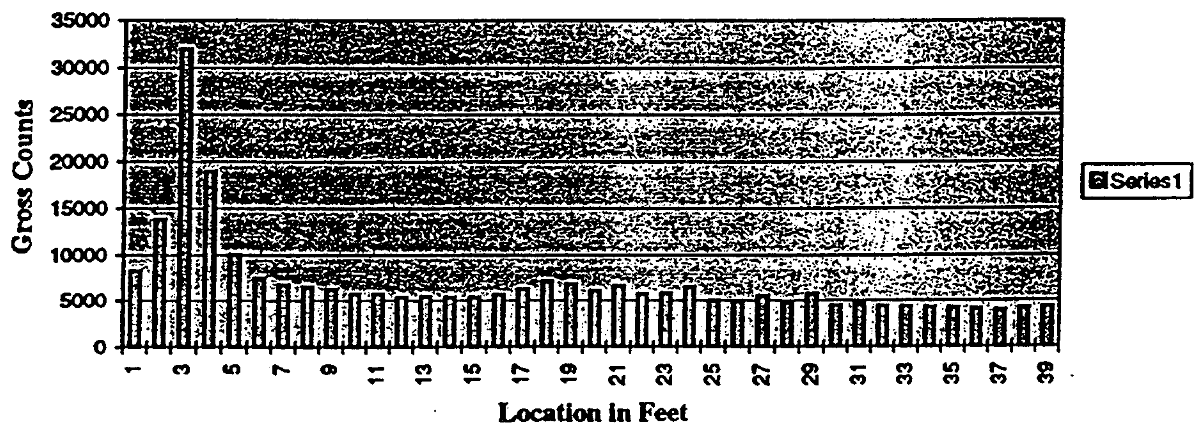
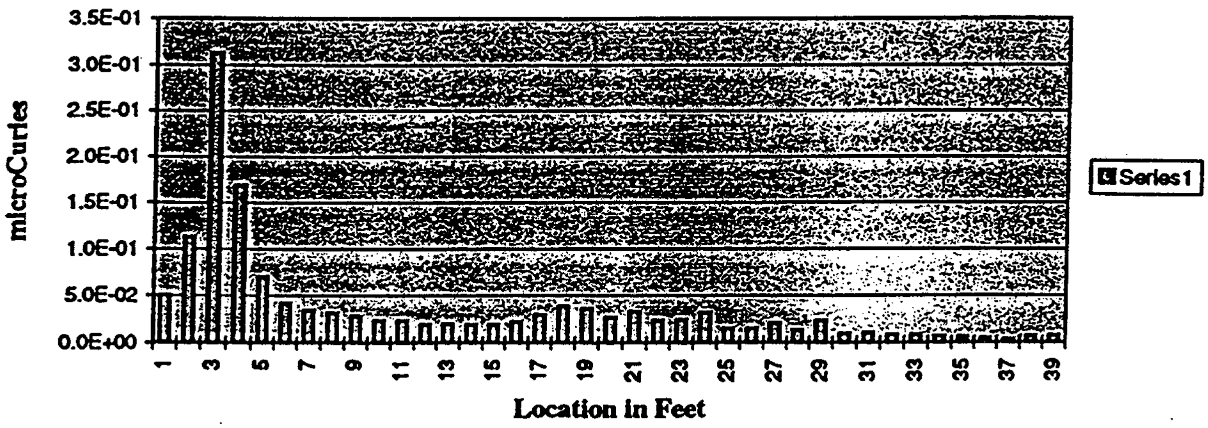


Figure 400. 36. External Survey of Pipe From DU Room and Room 204 Just Outside of Room 113 to Main Overhead Drain, RSR # 13.



There is an area of significant activity in this pipe where it exits the wall an makes a 90 degree bend. Indeed the pipe shows significant activity along the length of the pipe. The x-axis in figures 400.35 and 400.36 shows 39 measurements. This is due to the fact that some measurements were taken more than once to verify the presence of activity. These locations were 17A, 21A and 21b. These were measurements taken near the first location (within about 6 inches) that yielded the highest count rate. The measurements at 26-1, 26-2 and 26-3 represent measurements made along a pipe that enters this line from the eye wash station from room 204 on the second deck.

Room 112 Main Overhead Drain From South Wall To North Wall

This section continues the survey of the main overhead drain after it penetrates the south wall of room 112 and traverses the overhead space to where it ties into the Building 400 North wall down comer

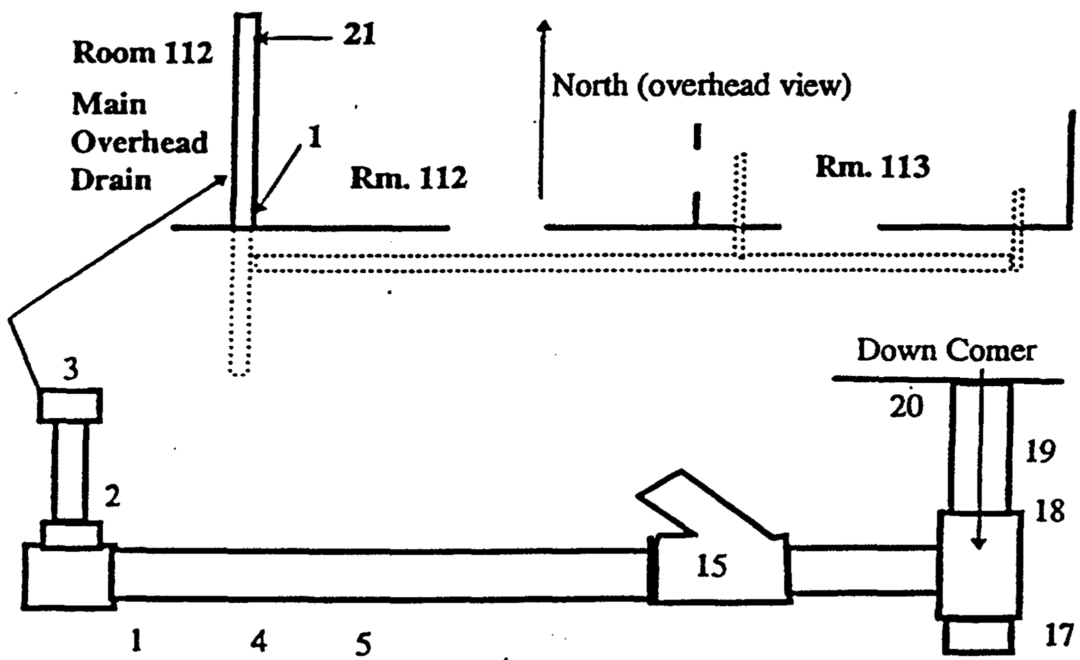


Figure 400. 37	Main overhead drain line from south wall of room 112 to North wall down comer.

North
(side view)

Figure 400. 38. Main Overhead Drain Line Survey in Room 112 from South Wall to North Wall Down Comer, RSR #14.

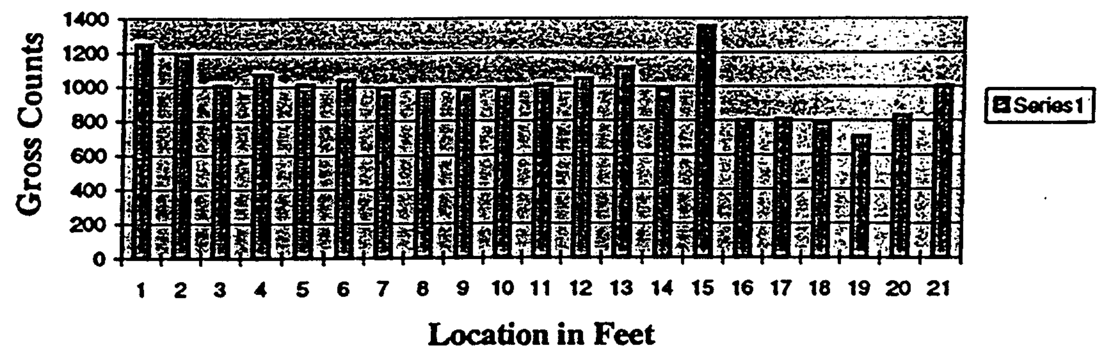
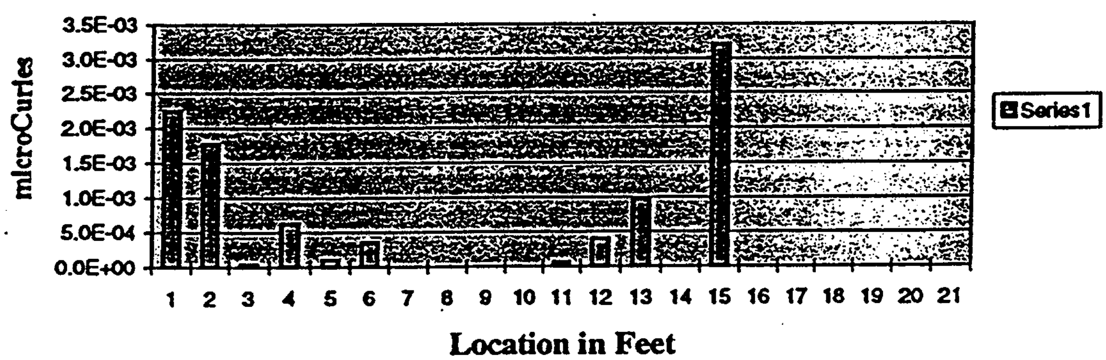


Figure 400. 39. Main Overhead Drain Line Survey in Room 112 from South Wall to North Wall Down Comer, RSR # 14.



Room 112 North Wall Down Comer Pipe

The Main overhead drain empties into a large down comer descending the North wall of room 112. This pipe exits the room near the floor through the north wall. The exterior survey results are attached.

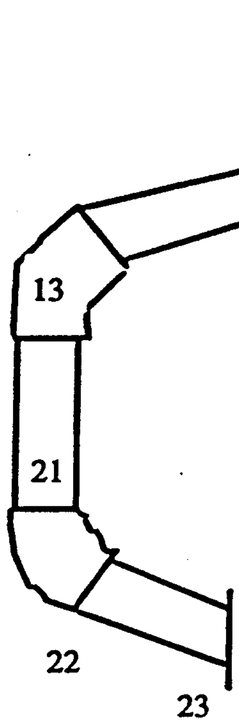


Figure 400. 40 Survey of room 112 North wall down comer

Figure 400. 41 . Room 112 North Wall Comer Below Main Overhead Drain, RSR # 15.

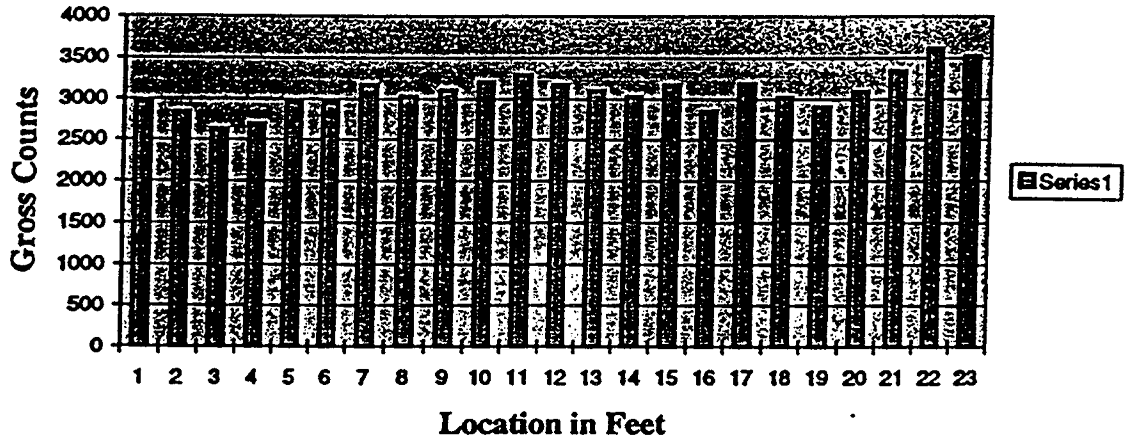
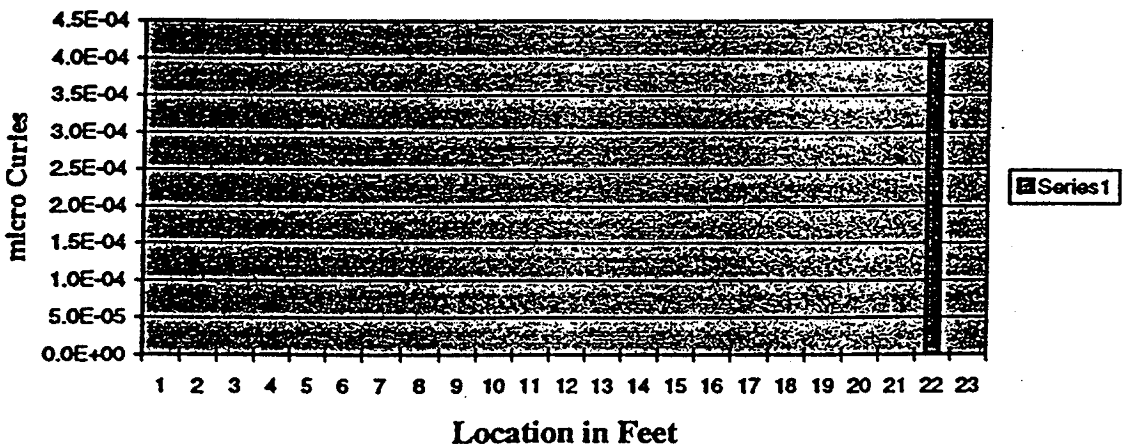


Figure 400. 42 . Room 112 North Wall Comer Below Main Overhead Drain, RSR # 15.



Room 203 Sink Drain

In the overhead pipe area in room 112 it was noticed that a 2 inch ID line extended from the second deck from room 203 above. This line empties into the main overhead drain where it exits the south wall into room 112. We were directed by Mr. Hutchison to survey the line from the ceiling to the first elbow. No activity above L_D was noted.

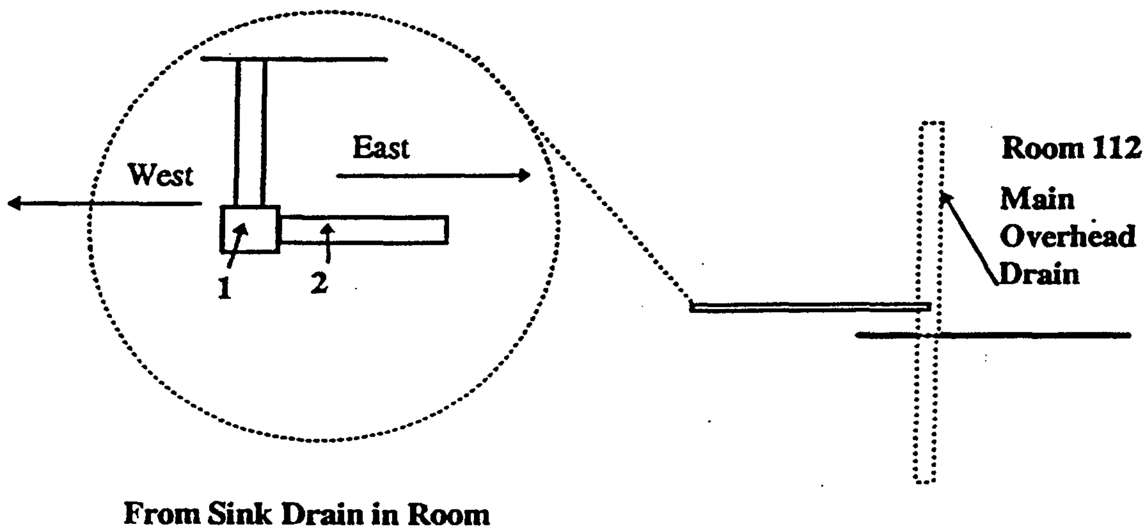


Figure 400. 43. Survey of elbow from room 203 sink drain in room 112 overhead space.

Figure 400. 44. Elbow of Sink Drain From Room 203 in Overhead of Room 112, RSR # 16.

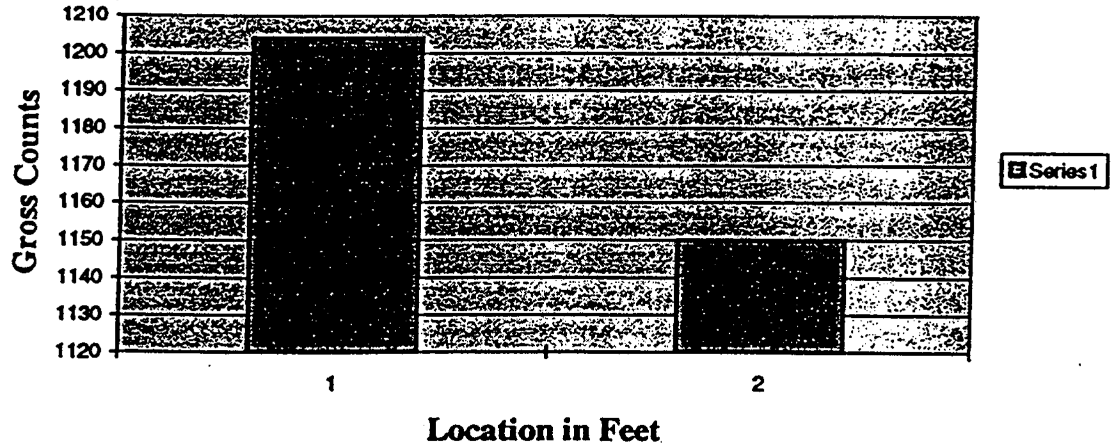
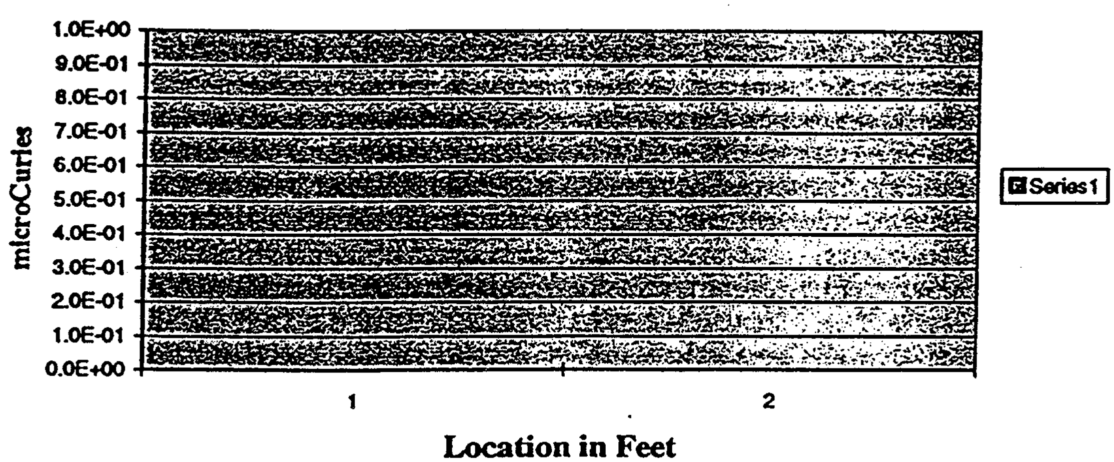


Figure 400. 45. Elbow of Sink Drain From Room 203 in Overhead of Room 112, RSR # 16.



New World Technology
Radiological Survey Report

Date:	9/13/96	Time:	1600	Surveyor (print): Don Wadsworth
Surveyor Signature:		Reviewed by:		
Purpose of Survey:	Survey of interior of pipe starting in paint spray booth, 2 inch ID line			
Location:	Building 400, second deck, room 213 paint spray booth			

Instruments Used

#	Model	Serial No.
1	Bicron Labtec	A075F
2	G1LE 1"x0.04" NaI	A774J

Bkg	Source (nCi)	Source CPM
175	23.1	438

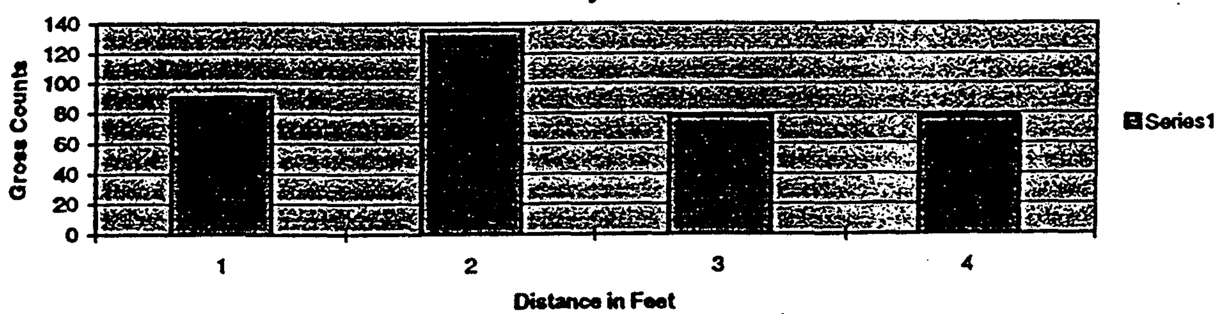
Efficiency: 0.005

Net counts for LD: 64 cpm **LD:** 5.64 nCi 0.0056 µCi

Survey Results

#	Item or Location	Gross Count	Count Time (min)	Bkg	Counts - Bkg	Activity (µCi)	Remarks
1	Pipe Interior	91	1	175	-84	0.0E+00	Activity is below LD
2	Pipe Interior	136	1	175	-39	0.0E+00	Activity is below LD
3	Pipe Interior	78	1	175	-97	0.0E+00	Activity is below LD
4	Pipe Interior	77	1	175	-98	0.0E+00	Activity is below LD

Figure 400.3 Bldg. 400, Room 213 Paint Spray Booth Interior Drain Line Survey RSR #1



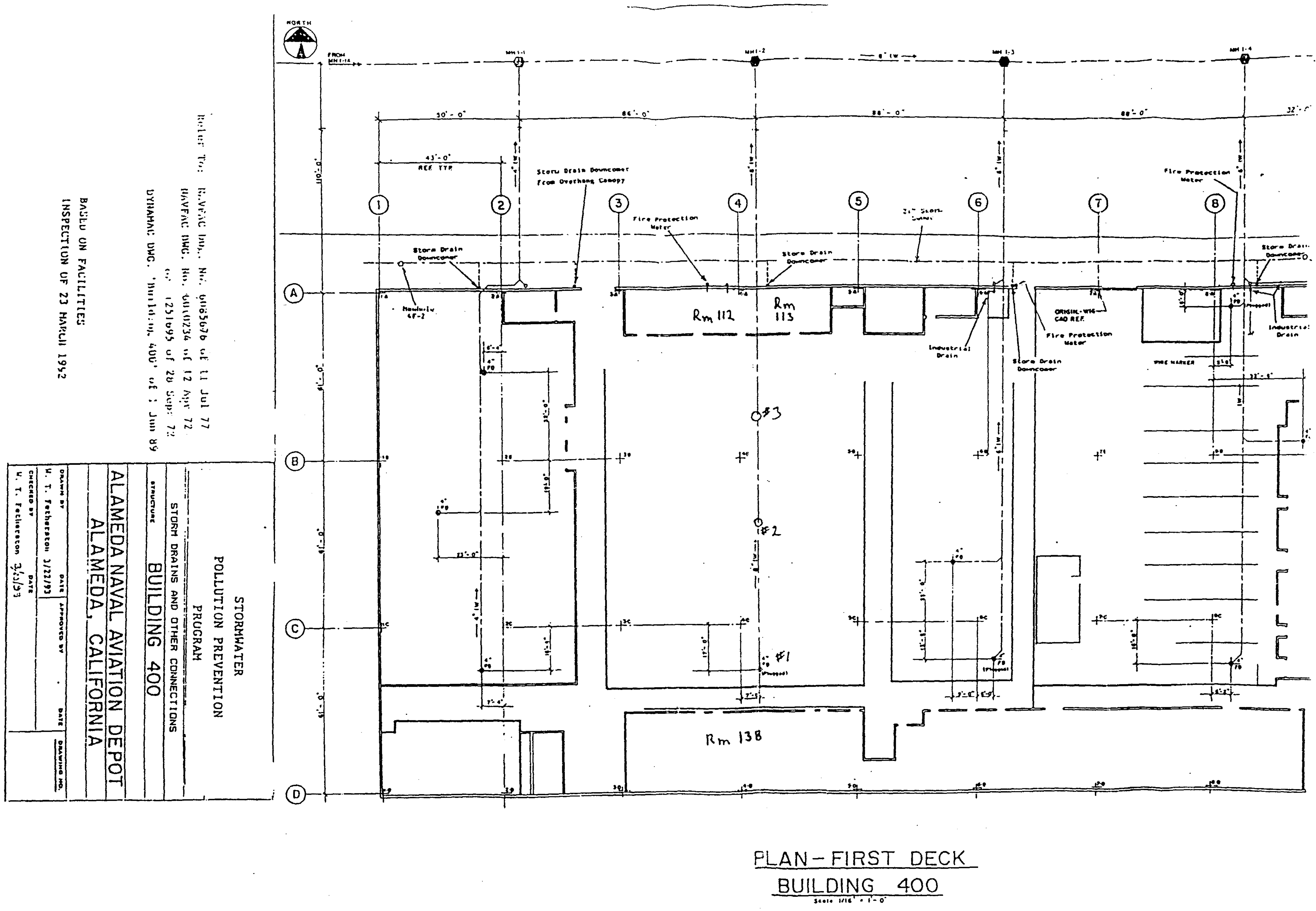
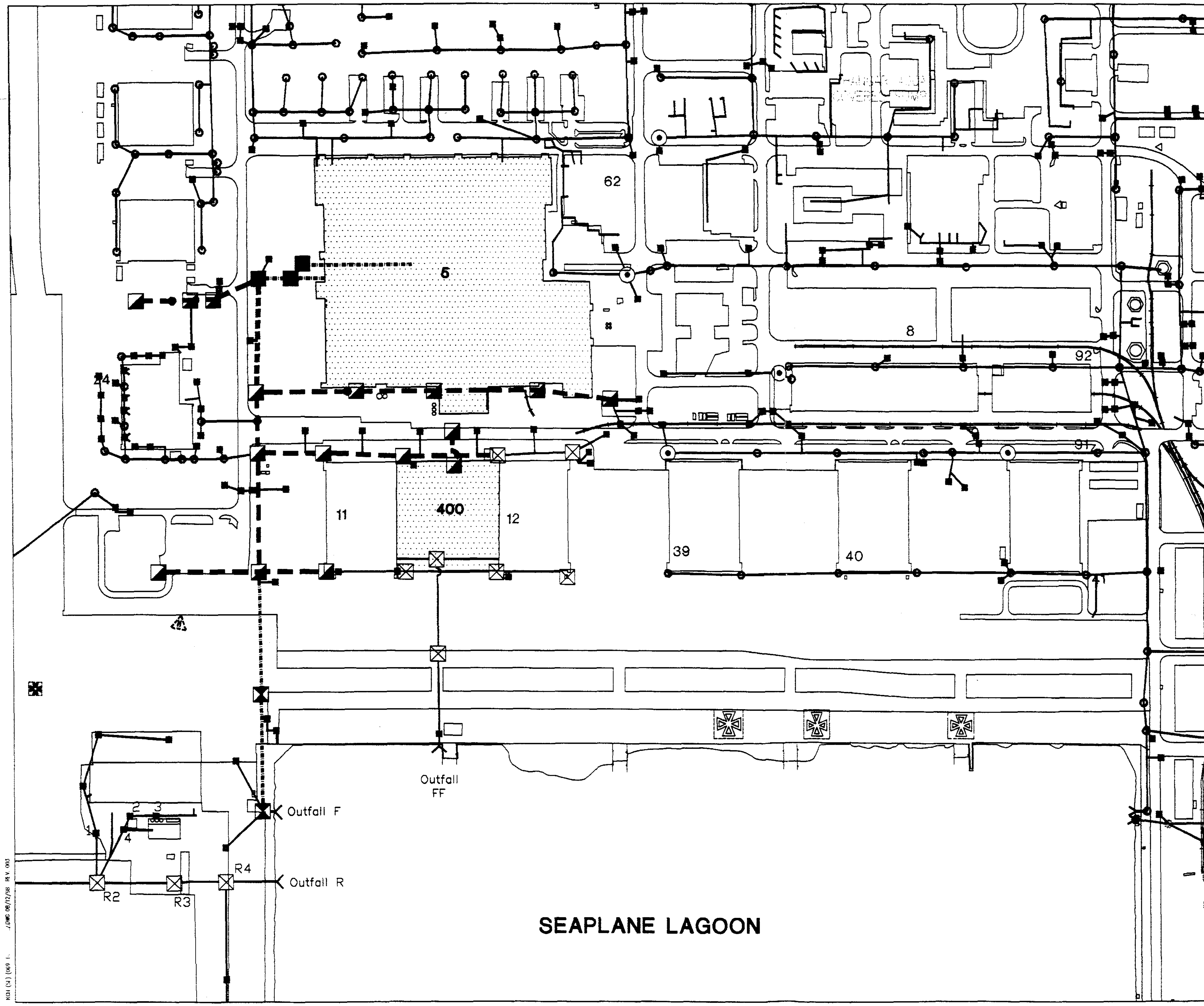


Figure 5

INDUSTRIAL WASTE GRAVITY SEWER
FIRST DECK
BUILDING 400



LEGEND

MANHOLE/CATCH BASIN LOCATION MAXIMUM ACTIVITY DETECTED > 10^8 pCi Ra-226

SEWER SYSTEM LINE MAXIMUM ACTIVITY DETECTED > 10^8 pCi Ra-226

MANHOLE/CATCH BASIN LOCATION MAXIMUM ACTIVITY DETECTED > 10^6 pCi Ra-226 < 10^8 pCi Ra-226

SEWER SYSTEM LINE MAXIMUM ACTIVITY DETECTED > 10^6 pCi Ra-226 < 10^8 pCi Ra-226

MANHOLE/CATCH BASIN LOCATION MAXIMUM ACTIVITY DETECTED > 10^4 pCi Ra-226 < 10^6 pCi Ra-226

SEWER SYSTEM LINE MAXIMUM ACTIVITY DETECTED > 10^4 pCi Ra-226 < 10^6 pCi Ra-226

NO APPRECIABLE DIFFERENCE FROM BACKGROUND (< 10^4 pCi Ra-226)

BACKGROUND MANHOLE

SEWER SYSTEM MANHOLE LOCATION

SEWER SYSTEM CATCH BASIN LOCATION

SEWER SYSTEM LINE

SOURCES: "RADIATION SURVEY REPORT, NAVAL AIR STATION, ALAMEDA, CALIFORNIA", PRE-DRAFT FEBRUARY 1997.

"ALAMEDA NAVAL AIR STATION, RADIOLOGICAL CHARACTERIZATION SURVEY OF STORM DRAINS," FINAL REPORT FOR COMMENT.

N

150 0 150 300

SCALE: IN FEET

NAS ALAMEDA, CALIFORNIA

Figure 6

SITES 5 & 10 – BUILDINGS 5 & 400 EXTERIOR STORM DRAIN LINES & SEWERS

ENGINEERING FIELD ACTIVITY WEST

APPENDIX C

PRIOR RADIOLOGICAL SURVEYS

FORMER RADIOACTIVE WASTE STORAGE SHACK AREA ANOMALIES

Anomaly	Initial Count Rate [a] (cpm)	Initial Exposure Rate [b] (μR/hr)	Source Recovered	Final Count Rate [c] (cpm)	Final Exposure Rate [b] (μR/hr)
SS01	134,382	24-26	Yes	169,124	32
SS02	7,005	17-18	No	n/a	n/a
SS03	7,300	13-14	Yes	634	6-7
SS04	19,389	10-11	No	n/a	n/a
SS05	104,305	30	Yes	11,292	15-17
SS06	4,492	10-11	Yes	3,534	9-10
SS07	4,713	9-10	Yes	1,116	8-9
SS08	31,075	19	Yes	9,397	9-10

Notes:

a - net count rate on the ground surface prior to excavation

b - taken at 1 meter above the ground surface

c - net count rate on the ground surface after excavation

n/a - no source recovered, count rates increased with depth

μR/hr - microRoetgen per hour

cpm - counts per minute

BETA ACTIVITIES FOR FLOOR ANOMALIES IDENTIFIED IN BUILDING 5 BEARING SHOP

Location	Activity ($dpm/100cm^2$)	Location	Activity ($dpm/100cm^2$)	Location	Activity ($dpm/100cm^2$)
B5-F-A	490 ± 370	B5-F-L	1,500 ± 500	B5-F-W	1,500 ± 510
B5-F-B	<470	B5-F-M	1,800 ± 540	B5-F-X	1,200 ± 470
B5-F-C	<220	B5-F-N	1,100 ± 460	B5-F-Y	1,600 ± 510
B5-F-D	<100	B5-F-O	3,400 ± 700	B5-F-Z	1,700 ± 530
B5-F-E	490 ± 370	B5-F-P	2,100 ± 580	B5-F-AA	1,400 ± 500
B5-F-F	<440	B5-F-Q	1,500 ± 500	B5-F-BB	1,800 ± 540
B5-F-G	<400	B5-F-R	1,200 ± 470	B5-F-CC	1,300 ± 480
B5-F-H	<230	B5-F-S	1,500 ± 500	B5-F-DD	1,000 ± 440
B5-F-I	1,700 ± 530	B5-F-T	2,100 ± 570	B5-F-EE	1,300 ± 480
B5-F-J	1,600 ± 520	B5-F-U	1,700 ± 520	B5-F-FF	1,900 ± 550
B5-F-K	1,200 ± 470	B5-F-V	1,800 ± 540	B5-F-GG	1,400 ± 490

Notes:

$dpm/100cm^2$ - disintegrations per minute per 100 square centimeters

BETA ACTIVITIES FOR WALL ANOMALIES IDENTIFIED IN BUILDING 5 BEARING SHOP

Anomaly Location	Beta Activity (dpm/100cm^2)	
	Gas Proportional Detector [a]	GM Detector [b]
B5-W-A	2,012 ± 80	2,169 ± 414
B5-W-B[c,d]	4,752 ± 116	9,939 ± 1,559
B5-W-C0	606 ± 52	1,795 ± 386
B5-W-C1	373 ± 46	330 ± 247
B5-W-C2	359 ± 45	n/a
B5-W-C3	965 ± 60	1,000 ± 318
B5-W-C4	1,010 ± 61	1,125 ± 329
B5-W-C5	423 ± 47	377 ± 253
B5-W-C6	263 ± 42	n/a
B5-W-D	293 ± 43	n/a
Bkgd.	n/a	n/a

Notes:

GM - Geiger-Mueller

dpm/100cm^2 - disintegrations per minute per 100 square centimeters

a - L_D = 58 dpm/100cm^2, assumes no shielding

b - L_D = 383 dpm/100cm^2, assumes no shielding

c - Above the 3,000 dpm/100cm^2 maximum concentration release limits for some beta-emitting isotopes (USAEC 1974)

d - A one-minute gamma count using the 2x2 NaI gamma scintillation detector at this location had a net gamma count rate of 2,145 cpm above background. The exposure rate on contact with the anomalous location was 11 to 12 μR/hr

n/a - Not able to pinpoint a small area of elevated activity; not applicable

Bkgd. - Background count rate (cpm)

BUILDING 400 ALPHA ANOMALIES THAT EXCEED THE RELEASE LIMIT FOR FIXED ALPHA SURFACE ACTIVITY

Room Number	Location / ID Number [a]	Total Alpha Activity [b] (dpm/100cm^2)
210	Floor / D	467 ± 74
210	Floor / G	370 ± 66
204	Lower beam / 01	1,006 ± 108
204	Concrete ledge / 02	669 ± 89
204	North wall / 03	1,613 ± 137
204	North wall / 04	1,607 ± 137

Note:

dpm/100cm^2 - disintegrations per minute per 100 square centimeters

a - identified on Figures 4-25 and 4-29

b - Release limit for fixed alpha surface activity is 300 dpm/100 cm^2

SUMMARY OF BUILDING 400 DRAIN LINE ANOMALIES

Building 400 Drain Line Survey Location	Measurement Number	Estimated Radium-226 Activity (nCi)
Drain line from Room 213 to the first floor main overhead drain line (see Figure 4-32)	29	29
South wall downcomer from Room 213 to Room 138 (first floor) (see Figure 4-33)	22	15 [a]
First floor main overhead drain line from Room 112 to Room 138 (see Figure 4-34)	1	11 [a]
First floor overhead drain line in Room 113 from the south wall to the north wall (see Figure 4-35)	8	11 [a]
First floor overhead drain line from Room 204 to Room 112 (see Figure 4-36)	3	313 [b]
Industrial waste sewer line from manhole R112 (north side of Building 400 in the middle of Avenue F) towards Building 400 (see Figure 4-37)	43	8,540 [c]

Notes:

a - gross counts less than twice background

b - maximum activity in the line (75 percent of all measurements were greater than 5 times the L_D)

c - maximum activity in the line (all measurements greater than 8 times the L_D)

nCi - nanoCuries

ANOMALOUS STORM SEWER MANHOLES AND MAXIMUM ACTIVITIES

Manhole Number	Maximum Point-Source Equivalent Activity for Radium-226 (nCi)
3F	208
4F	123
4F-1	65
4F-2	105
5F	133
6F	1,624
6F-1	2,720
6F-2	1,346
Industrial Waste Sewer Manhole R112	54

MAXIMUM GROSS GAMMA COUNT RATES AND POINT-SOURCE EQUIVALENT ACTIVITIES FOR RADIUM-226 IN STORM SEWER LINE F

Survey Section Storm Sewer Line F	Measurement Number	Maximum Gross Gamma Count Rates (cpm)	Point-Source Equivalent Activity for Radium-226 (nCi)
Manhole 6F to 5F	69	5,900,000	470,000
Manhole 5F to 4F	22	11,000	150
Manhole 4F to 3F	233	12,000	280
Manhole 3F to 45 feet south of 3F	10	2,200	36

Notes:

cpm - counts per minute

nCi - nanoCuries

APPENDIX D

MISCELLANEOUS RADIOLOGICAL INFORMATION

SURFACE RADIOACTIVITY LIMITS FOR RELEASE OF MATERIALS

Radionuclides[2/]	Allowable Total Residual Surface Contamination (dpm/100 cm^2)[1/]		
	Average[3/4/]	Maximum[4/5/]	Removable[4/6/]
Transuranics, I-125, I-129, Ra-226, Ac-227, Ra-228, Th-228, Th-230, Pa-231	100	300	20
Th-nat, Sr-90, I-126, I-131, I-133, Ra-223, Ra-224, U-232, Th-232	1,000	3,000	200
U-nat, U-235, U-238, and associated decay products	5,000	15,000	1,000
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.[7/]	5,000	15,000	1,000

1/ As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

2/ Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

3/ Measurements of average contamination should not be averaged over more than 1 m^2. For objects of less surface area, the average should be derived for each such object.

4/ The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h or 1.0 mrad/h, respectively, at 1 cm.

5/ The maximum contamination level applies to an area of not more than 100 cm^2.

6/ The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wiping with an appropriate instrument of known efficiency. When removable contamination of objects of less surface area is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. It is not necessary to use wiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination.

7/ This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them. It does not apply to Sr-90 which has been separated from other fission products or mixtures where the Sr-90 has been enriched.

Source: USNRC Regulatory Guide 1.86, June 1994.

Radiation Survey Forms

GRID SURVEY DATA WORKSHEET

CLEAN Program Form Serial No.

Project	CTO	Task	Date
Building / No.	Building Description	Survey Section	Additional Identifier
Originator:	Employer/Employee No.	Date	
Measurement Purpose	Dataset Identifier	Count Time (min)	
Type of Survey ((α,β,χ,,β-χ)	Instrument Model	Instrument No.	Background Count Rate
Measurement Purpose	Detector Model	Detector No.	Net Count Action Level
Activity Conversion Factor	Set-up Reference	Control Reference	

Grid Sketch (highlight primary gridlines) Record Activity in Net Counts per minute (CPM)

	1	2	3	4	5	6	7	8	9	0		
A												
B												
C												
D												
E												
F												
G												
H												
J												
K												

Area Above Action Level	Area Below Action Level
Average Activity Above Action Level (cpm)/(activity / 100 cm^2)	Average Net Activity Below Action Level (cpm)/(activity / 100 cm^2)
Average Activity (cpm)/(activity / 100 cm^2)	Blocks Represent Area (cm x cm)
Clean Up Goal	Action

Review		***Action***
		File
Completed By:	Date	File
Review By:	Date	Repair
Validation	Date	

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DETECTOR PLATEAU SETUP WORKSHEET CLEAN Program

Form Serial No.

Project	CTO	Task	Date
Building / No.	Building Description	Survey Section	Additional Identifier
Originator:	Employer/Employee No.	Date	Instrument Number
CASE	Dataset Identifier	Count Time (min)	
Type ((α,β,χ,,β-χ)	Instrument Model	Instrument No.	Background Count Rate
Measurement Purpose	Detector Model	Detector No.	Net Count Action Level
Activity Conversion Factor	Set-up Reference		

Record Measurement Value in Net Counts per minute (CPM)

Response

Voltage 550 600 650 700 750 800 850 900 950 1000 1050 1100 1150 1200 1250 1300 1350 1400 1450

CALCULATIONS

Review		***Action***
Completed By:	Date	File
Review By:	Date	File
Validation	Date	Repair

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Radiation Surv cord (Scan/Swipe)

CTO ________ Site/Task ____________________ Surveyor ____________________ Employee No. ____________________ Employer ____________________

Instrument SN ____________ Instrument Type ____________________ Last Calibration Date ____________________ Cal. By. ____________________

Check Source Type __________ Activity ____________________ Check Source No. ____________ Response ____________________ Background ____________

Survey Date: ____________________ Calibration Factor: ____________ Count Time ________ Scan Rate ____________________ Swipe Count Time ________

Additional Set Up Notes: ________________________________ Instrument ________ T ________ HV ________ Win ____________________ Probe Area ____________

Location Grid/Item Description	Instrument A/B	Gross Count	Surface Act dpm/100 cm^2	Scan Max. Rate	Swipe Area (cm^2)	Swipe Gross Counts	Swipe Net or corrected result	Surveyor Notes	Validation Code

Completed By: ____________________ Sign ____________________ Date ________

Reviewed By: ____________________ Sign ____________________ Date ________

Validation ____

Radiation Survey Map

CTO ________ Site/Task __________ Surveyor ___________ Employee No. ________ Employer __________ Survey Date: __________

Instrument ________ Calibration No. ______ Check Source No. _____ Response ______ Background ___________ Background Time ______

Additional Set Up Notes: ____

Grid Sketch (highlight primary gridlines)

	1	2	3	4	5	6	7	8	9	0	10	11	12
A													
B													
C													
D													
E													
F													
G													
H													
J													
K													
L													
M													
N													

Notes:

Completed By: ________________ Sign ________________ Date ________

Reviewed By: ________________ Sign ________________ Date ________

Validation ________________

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Radiation Survey Map

CTO _____ Site/Task _____________ Surveyor ____________ Employee No. _________ Employer ___________ Survey Date: ___________

-trument __________ Calibration No. _______ Check Source No. _____ Response _______ Background ___ Background Time ______

..ditional Set Up Notes: ____

Sketch

Notes:

Completed By:	Sign	Date
Reviewed By:	Sign	Date

ʼion

Radiation Grid Survey Record (Walkover)

CTO ________ Site/Task ____________________ Surveyor ____________________ Employee No. ________________ Employer ____________________

Instrument SN ______________ Instrument Type ____________________ Last Calibration Date ______________ Cal. By. ________ Set-Up Ref ____________________

Check Source Type __________ Activity ____________________ Check Source No. ____________ Response ____________________ Background ______________

Survey Date: ______________ Calibration Factor: ____________ Grid Count Time__________ Scan Rate ____________________ Swipe Count Time ________

Additional Set Up Notes: ________________________________ Instrument________ T________ HV________ Win________________ Probe Area______________

Location Grid/Item Description	Coordinate			Gross Count	Surface Act dpm/100 cm^2	Scan Max. Count Rate	Meets Release Limit	Surveyor Notes	Validation Code

Completed By: ______________________ Sign ______________________ Date __________

Reviewed By: ______________________ Sign ______________________ Date __________

Validation ____

SPECIAL SURVEY DATA RECORD

CLEAN Program Form Serial No.

Project	CTO	Task	Date

Building / No.	Building Description	Survey Section	Additional Identifier

Originator:	Employer/Employee No.

Measurement Purpose	CASE	Count Time (min)

Type of Survey ((α,β,λ,β-λ)	Instrument Identifiers	Background Count Rate

Activity Conversion Factor	Set-up Reference	Control Chart Reference

Item Description

Sketch Survey Details Record Activity in Net Counts per minute (CPM)

Review		***Action***
Completed By:	Date	File
Review By:	Date	File
Validation	Date	Repair

CONTROL CHART DATA WORKSHEET

CLEAN Program Form Serial No.

Accuracy

Project	CTO	Task	Date

Building / No.	Building Description	Survey Section	Additional Identifier

Originator:	Employer/Employee No.	Additional Data

Calibration No.	Dataset Identifier	Count Time (min)

Type of Survey ((α,β,γ,β-γ)	Instrument Model	Instrument No.	Background Count Rate
Measurement Purpose	Detector Model	Detector No.	Net Count Action Level

Activity Conversion Factor	Set-up Reference	Project Detector No.

Record Measurement Value in Net Counts per minute (CPM)

σ	M	T	W	R	F	S	M	T	W	R	F	S	M	T	W	R	F	S
Day																		
+3.2																		
+3.0																		
+2.8																		
+2.6																		
+2.4																		
+2.2																		
+2.0																		
+1.8																		
+1.6																		
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+1.2																		
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+0.4																		
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-2.0																		
-2.2																		
-2.4																		
-2.6																		
-2.8																		
-3.0																		
-3.2																		
Day	M	T	W	R	F	S	M	T	W	R	F	S	M	T	W	T	S	

CALCULATIONS

$X - \mu / \sigma$ = normalized deviation

$\sigma = (x - x_i)^2 / x_{bar}$

$x_{bar} = (\Sigma x_i) / n$

Control limits for means

$UCL = x_{bar} + t_{(1-\alpha/2),n} \times (\sigma / n^{½}$

$LCL = x_{bar} - t_{(1-\alpha/2),n} \times (\sigma / n^{½})$

Review		*Action*
Completed By:	Date	File
Review By:	Date	File
Validation	Date	Repair

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CONTROL CHART DATA WORKSHEET CLEAN Program Form Serial No.

Precision (RPD)

Project	CTO	Task	Date

Building / No.	Building Description	Survey Section	Additional Identifier

Originator:	Employer/Employee No.	Additional Data

RPD (%) = $100 \times (x_1 - x_2) / (x_1 + x_2 / 2)$	Dataset Identifier	Count Time (min)

Type of Survey (($\alpha,\beta,\gamma,\beta$-$\gamma$)	Instrument Model	Instrument No.	Background Count Rate
Measurement Purpose	Detector Model	Detector No.	Net Count Action Level

Activity Conversion Factor	Set-up Reference	

Record Measurement Value in Net Counts per minute (CPM)

%	σ Day	M	T	W	R	F	S	M	T	W	R	F	S	M	T	W	R	F	S
	+32																		
	+30																		
	+28																		
	+26																		
	+24																		
	+22																		
	+20																		
	+18																		
	+16																		
	+14																		
	+12																		
	+10																		
	+08																		
	+06																		
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	-22																		
	-24																		
	-26																		
	-28																		
	-30																		
	-32																		
	Day	M	T	W	R	F	S	M	T	W	R	F	S	M	T	W	R	F	S

CALCULATIONS

$X - \mu / \sigma$ = normalized deviation

$\sigma = (x - x_i)^2 / x_{bar}$

$x_{bar} = (\Sigma x_i) / n$

Control Limits for means

$UCL = x_{bar} + t_{(1-\alpha/2),n} \times (\sigma / n^{1/2})$

$LCL = x_{bar} - t_{(1-\alpha/2),n} \times (\sigma / n^{1/2})$

Review		*Action*
Completed By:	Date	File
Review By:	Date	File
Validation	Date	Repair

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CONTROL CHART DATA WORKSHEET

CLEAN Program Form Serial No. ______

Project	CTO	Task	Date

Building / No.	Building Description	Survey Section	Additional Identifier

Originator:	Employer/Employee No.	Date	Checksource ID

Measurement Purpose Calibration Accuracy Other	Dataset Identifier	Count Time (min)

Type of Survey (α β γ β-γ)	Instrument Model	Instrument No.	Background Count Rate
Measurement Purpose	Detector Model	Detector No.	Net Count Action Level

Activity Conversion Factor	Detector CASE (Set-up Reference)	

Record Measurement Value in Net Counts per minute (CPM)

σ	M	T	W	R	F	S	M	T	W	R	F	S	M	T	W	R	F	S
Day																		
Day	M	T	W	R	F	S	M	T	W	R	F	S	M	T	W	R	F	S

CALCULATIONS

X - μ / σ = normalized deviation

$CL = \mu \pm t_{df} \times \sigma / \sqrt{(n-1)}$

df	**1**	**5**	**10**	**15**	**20**	**25**	**30**	**∞**
t95	12..70	2.57	2.23	2.13	2.08	2.06	2..04	1..645
df	**1**	**5**	**10**	**15**	**20**	**25**	**30**	**∞**
t98	31.82	3.36	2.76	2.60	2.53	2.48	2.46	1..645

Review		***Action***
Completed By:	Date	File
Review By:	Date	File
Validation	Date	Repair

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CONTROL CHART DATA WORKSHEET

CLEAN Program

Form Serial No.

Project	CTO	Task	Date
Building / No.	Building Description	Survey Section	Additional Identifier
Originator:	Employer/Employee No.	Date	Checksource ID
Measurement Purpose Calibration Accuracy Other		Dataset Identifier	Count Time (min)
Type of Survey (α β γ β-γ)	Instrument Model	Instrument No.	Background Count Rate
Measurement Purpose	Detector Model	Detector No.	Net Count Action Level
Activity Conversion Factor	Detector CASE (Set-up Reference)		

Record Measurement Value in Net Counts per minute (CPM)

σ	M	T	W	R	F	S	M	T	W	R	F	S	M	T	W	R	F	S
Day																		
+32																		
+30																		
+28																		
+26																		
+24																		
+22																		
+20																		
+18																		
+16																		
+14																		
+12																		
+10																		
+08																		
+06																		
+04																		
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-18																		
-20																		
-22																		
-24																		
26																		
-28																		
-30																		
-32																		
Day	M	T	W	R	F	S	M	T	W	R	F	S	M	T	W	R	F	S

CALCULATIONS

$X - \mu / \sigma$ = normalized deviation

$CL = \mu \pm t_{df} \times \sigma/\sqrt{(n-1)}$

df	**1**	**5**	**10**	**15**	**20**	**25**	**30**	**∞**
t95	12..70	2.57	2.23	2.13	2.08	2.06	2..04	1..645
df	**1**	**5**	**10**	**15**	**20**	**25**	**30**	**∞**
t98	31.82	3.36	2.76	2.60	2.53	2.48	2.46	1..645

Review		***Action***
Completed By:	Date	File
Review By:	Date	File
Validation	Date	Repair

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Radiation Survey Record (Direct Count/Swipe)

CTO _________ Site/Task ___________ Surveyor ____________ Employee No. ____________ Employer _________________

Instrument __________ Calibration No. _________________ Case _______________________

Check Source No. _____________ Response _______________ Background ________________ Background Time ______

Survey Date: ___________ Calibration Factor: _______Count Time__________Scan Rate_________ Swipe Count Time _____

Additional Set Up Notes: ____

Location Grid/Item Description	Instrument	Sample No.	Gross Count	Swipe Area (cm^2)	Swipe Gross Count	Surveyor Notes	Validation Code

Completed By: ______________ Sign ______________ Date ______________

Reviewed By: ______________ Sign ______________ Date ______________

Validation ______________

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Rad Setup / Control Log

Detector No. ______________________

CTO __________ Site ______________________ Surveyor ______________ Date _______ Time _______ Employee No. ___________ Employer ______________________

Instrument SN _________ Instrument Type _______________ Inst. Model _______________ Last Calibration Date ___________ Cal. By. _____________ Cal. Due: ____________

Detector SN ________ __________ Detector Type _________________ Detector Model _______________ Last Calibration Date __________ Cal By: __________ Cal Due: __________

Check Source Type _____ Source No. ______ Serial No. _______ Activity (DPM) _______ Background _________________ Background Location _________ Nominal Response ________

Repeat Source Measurement							Calculations	Notes
Count	Single Source Response		Paired measurement				Count value (multiply by C_f to convert to dpm/100 cm^2)	
			1st of pair		2nd of pair			
	(cpm)	net	(cpm)	net	(cpm)	net	Mean source net response $r_{net} = r_s - r_b$	
1.							Standard deviation $s = 1/n\ \Sigma\ (x_i - x)^2$	L_c dpm/100 cm^2 =
2.								
3.								L_D dpm/100 cm^2 =
4.							UCL $(2\ \sigma) = r_{net} + 2\times1.96\ (r_s/t_s + r_b/t_b)^{1/2}$	
5.							LCL $(2\ \sigma) = r_{net} - 2\times1.96\ (r_s/t_s + r_b/t_b)^{1/2}$	
6.								
7.								
8.							Upper Warning Limit = UCL = $x_{bar} + t_{(1-\alpha/2),n} \times (\sigma / n^{1/2}\ )$	
9.							Lower Warning Limit = UCL = $x_{bar} + t_{(1-\alpha/2),n} \times (\sigma / n^{1/2}\ )$	
10.								
11.							UCL $(3\ \sigma) = r_{net} - 2\times1.96\ (r_s/t_s + r_b/t_b)^{1/2}$	
12.								
13.							Detection Limit $L_c = (1.65/\ t_s)\ (t_s\ r_b\ (1+t_s/t_b))^{1/2}$	
14.								
15.							Minimum Detectable Ac. $L_D = (1/\ t_s)(2.71+3.29(t_s\ r_b\ (1+t_s/t_b))^{1/2})$	
16.								
17.							Less than value when $r_{net} < L_c = r_s - r_b + 1.645\ (r_s/t_s + r_b/t_b)^{1/2}$	
18.								
19.							Correction Factor $C_f = 100\ cm^2 / \varepsilon\ A_p\ \ C$	
20.								

Completed By: ______________________ Sign ______________________ Date __________

Reviewed By: ______________________ Sign ______________________ Date __________

Validation ____

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Radiation Survey Record (Scan/Swipe)

CTO _________ Site/Task ____________________ Surveyor ____________________ Employee No. ______________________ Employer ____________________

Instrument SN _____________ Instrument Type ____________________ Last Calibration Date ________________________ Cal. By. ____________________________

Check Source Type ___________ Activity ___________________Check Source No. ____________ Response ___________________ Background _______________

Survey Date: ____________________ Calibration Factor: _____________Count Time_________Scan Rate_________________________Swipe Count Time _________

Additional Set Up Notes: _________________________________Instrument________T_________HV_________Win_________________Probe Area______________

Location Grid/Item Description	Instrument A/B	Gross Count	Surface Act dpm/100 cm^2	Scan Max. Rate	Swipe Area (cm^2)	Swipe Gross Counts	Swipe Net or corrected result	Surveyor Notes	Validation Code

Completed By: ______________________ Sign ______________________ Date __________

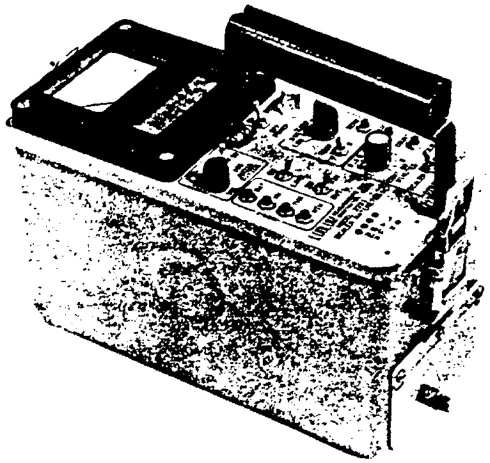
Reviewed By: ______________________ Sign ______________________ Date __________

Validation ____

Instrument Catalog Descriptions

Model 2221

SCALER/RATEMETER
SINGLE CHANNEL ANALYZER

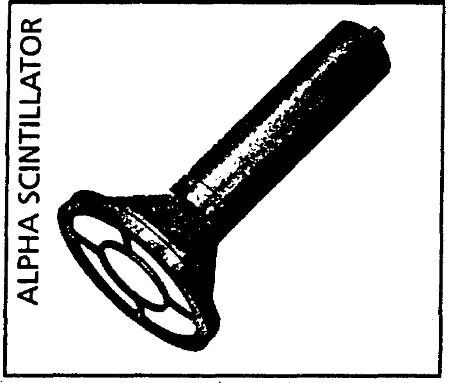


Specifications

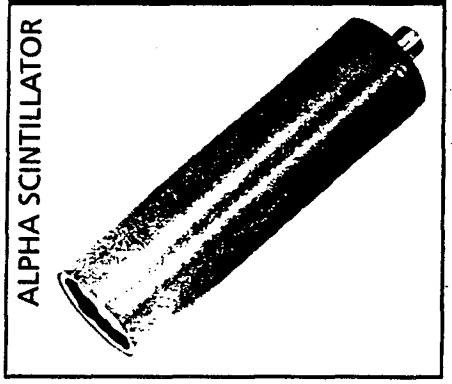
INDICATED USE: Field analysis
COMPATIBLE DETECTORS: G-M, proportional, scintillation
AUDIO: Built in unimorph speaker with volume control
AUDIO DIVIDE: Toggle switch for 1, 10, or 100 events-per-click
AUDIO JACK: For optional headset
METER DIAL: 0 - 500 cpm; 50 - 500k cpm logarithmic scale *(others available)*
MULTIPLIERS: X1, X10, X100, X1k, and LOG for logarithmic scale
DIGITAL DISPLAY: 6 digit LCD display with 0.5" (1.3cm) high digits
LCD BACKLIGHT: Activated by LAMP switch
DIGITAL RATEMETER: Provides a digital display of count rate when selector switch is in Dig. Rate position
SCALER: Used in conjunction with timer to allow for gross counting. Range from 0 - 999999 counts when selector switch is in Scaler position *(controlled by COUNT and HOLD buttons)*
***NOTE:** Scaler or digital ratemeter is active when not selected, allowing for concurrent use*
TIMER: Switch selectable divisions of 0.1, 0.5, 1, 2, 5, 10 minutes or CONT (*continuous*) for manual timing
HIGH VOLTAGE: Adjustable from 200 - 2400 volts *(can be checked on display)*
THRESHOLD: Adjustable from 100 - 1000 *(can be checked on display)*
WINDOW: Adjustable from 0 - 1000 above threshold setting *(can be turned on or off)*
GAIN: Adjustable from 1.5 - 100 mV at a threshold setting of 100
OVERLOAD: Senses detector saturation. Indicated by "– – – –" on LCD display and meter going to full scale *(adjustable depending on detector selected)*
POWER: 4 each "D" cell batteries
BATTERY LIFE: Typically 250 hours with alkaline batteries *(battery condition can be checked on digital display)*
SIZE: 9"(22.9cm)H X 4.3"(10.9cm)W X 10"(25cm)L including handle
WEIGHT: 5.5 lbs (2.5kg) including batteries

Alpha Scintillation

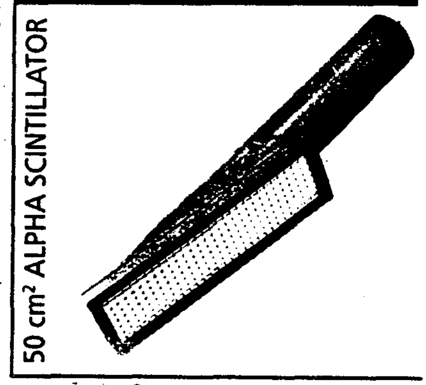
Model 43-1



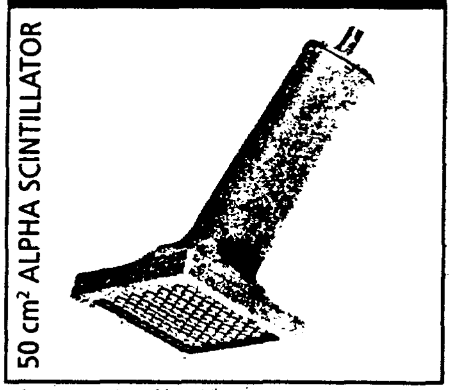
Model 43-2



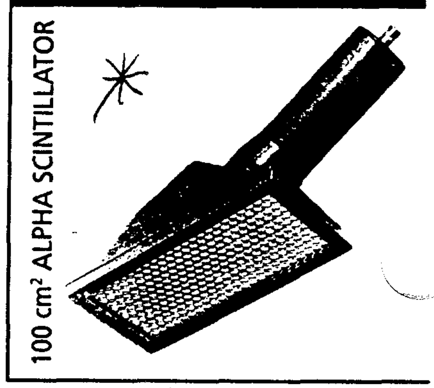
Model 43-5



Model 43-65



Model 43-90



Common Specifications

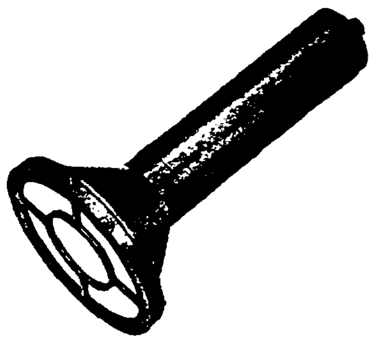
INDICATED USE: Alpha survey
SCINTILLATOR: ZnS(Ag)
WINDOW: Typically 0.8 mg/cm² aluminized mylar (*1.2 mg/cm² recommended for outdoor use*)
BACKGROUND: 3 cpm or less
NON-UNIFORMITY: Less than 10%
COMPATIBLE INSTRUMENTS: General purpose survey meters, ratemeters, and scalers
TUBE: 1.5" (3.8cm) diameter magnetically shielded photomultiplier
OPERATING VOLTAGE: Typically 500 - 1200 volts
DYNODE STRING RESISTANCE: 100 megohm

	43-1	43-2	43-5	43-65	43-90
WINDOW AREA	83 cm² active 75 cm² open	12 cm² active and open	76 cm² active 50 cm² open	63 cm² active 50 cm² open	125 cm² active 100 cm² open
EFFICIENCY (4pi gemometry)	35% - ^{239}Pu	30%-^{239}Pu 30%-^{230}Th	13%-^{239}Pu	17%-^{239}Pu 17%-^{230}Th	20%-^{239}Pu
SIZE	4.8"(12.2cm) diameter 9.8"(24.9cm)L	2"(5.1cm) diameter 7.3"(18.5cm)L	4"(10.2cm)H 2.5"(6.4cm)W 14"(35.6cm)L	7.5"(19-1cm)H 4"(10.2cm)W 6.5"(16.5cm)L	5.5"(13.9cm)H 4"(10cm)W 12.3"(33cm)
WEIGHT	2 lbs (0.9kg)	1 lb (0.5kg)	2 lbs (0.9kg)	1.4 lbs (0.6kg)	1.5 lbs (0.7kg)

Alpha Beta PhoSwich Scintillation

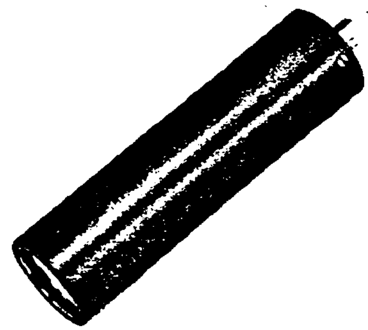
Model 43-1-1

ALPHA/BETA SCINTILLATOR



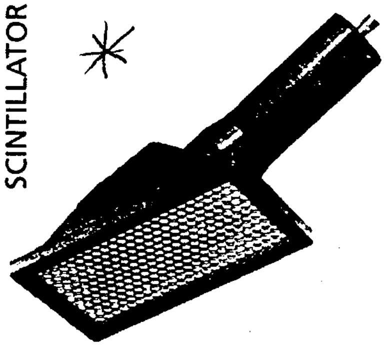
Model 43-2-2

ALPHA/BETA SCINTILLATOR



Model 43-89

100 cm^2 ALPHA/BETA SCINTILLATOR



Common Specifications

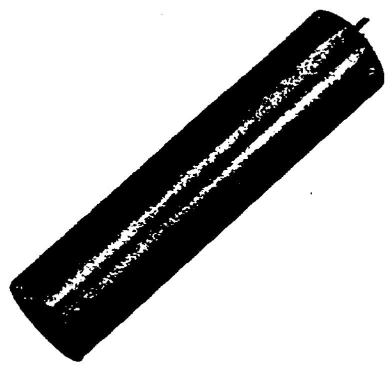
INDICATED USE: Alpha beta survey
SCINTILLATOR: ZnS(Ag) adhered to 0.010" thick plastic scintillation material
NON-UNIFORMITY: Less than 10%
CROSS TALK:
  Alpha to beta - less than 10%
  Beta to alpha - less than 1%
COMPATIBLE INSTRUMENTS: Models 2224, 2225, 2929
TUBE: 1.5"(3.8cm) diameter magnetically shielded photomultiplier
OPERATING VOLTAGE: Typically 500 - 1200 volts
DYNODE STRING RESISTANCE: 100 megohm

	43-1-1	43-2-2	43-89
WINDOW	0.8 mg/cm^2 aluminized mylar *(1.2 mg/cm^2 recommended for outdoor use)*		1.2 mg/cm^2
WINDOW AREA	83 cm^2 active 75 cm^2 open	12 cm^2 active and open	126 cm^2 active 100 cm^2 open
EFFICIENCY (4pi geometry)	30%-^{239}Pu; 30%-^{90}S/^{90}Y; 5%-^{14}C	25%-^{239}Pu; 30%-^{230}Th; 20%-^{90}S/^{90}Y; 5%-^{14}C	16%-^{239}Pu; 15%-^{99}Tc; 16%-^{90}S/^{90}Y
BACKGROUND	Alpha - 3 cpm or less Beta - Typically 300 cpm or less *(10 μR/hr field)*	Alpha - 3 cpm or less Beta - Typically 50 cpm or less *(10 μR/hr field)*	Alpha - 3 cpm or less Beta - Typically 300 cpm or less *(10 μR/hr field)*
SIZE	4.8"(12.2cm) diameter 9.8"(24.9cm)L	2"(5.1cm) diameter 7.3"(18.5cm)L	5.5"(13.9cm)H 4"(10cm)W 12.3"(33cm)L
WEIGHT	2 lbs (0.9kg)	1 lb (0.5kg)	1.5 lbs (0.7kg)

Gamma Scintillation

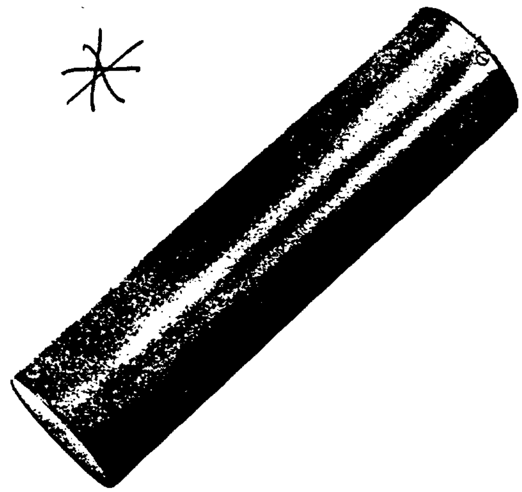
Model 44-2

GAMMA SCINTILLATOR



Model 44-10

GAMMA SCINTILLATOR

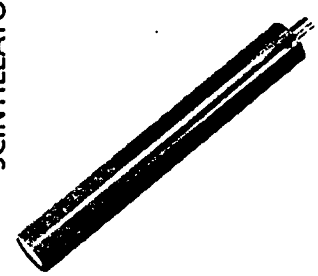


Common Specifications

INDICATED USE: High energy gamma detection
ENERGY RESPONSE: Energy dependent
COMPATIBLE INSTRUMENTS: General purpose survey meters, ratemeters, and scalers
OPERATING VOLTAGE: 500 - 1200 volts

Model 44-62

GAMMA SCINTILLATOR

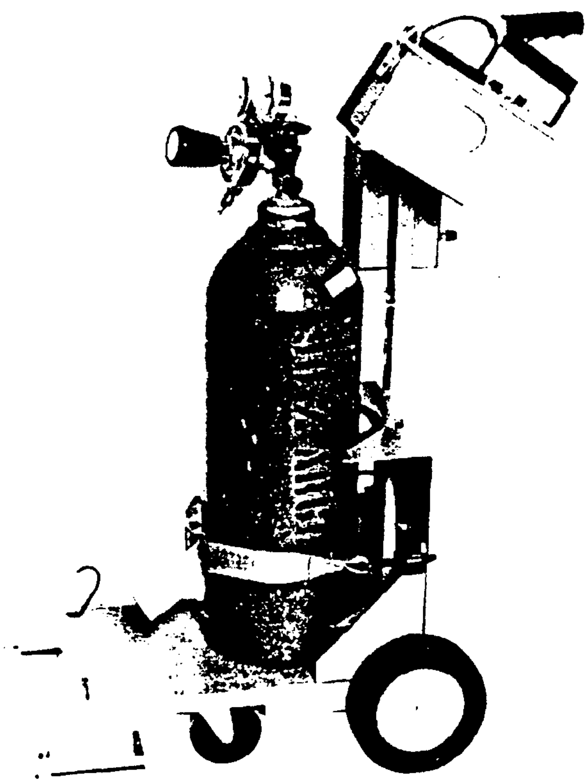


	44-2	44-10	44-62
SCINTILLATOR	1"(2.5cm) diameter 1"(2.5cm) thick NaI	2"(5.1cm) diameter 2"(5.1cm) thick NaI	0.5"(1.3cm) diameter 1"(2.5cm) thick NaI
SENSITIVITY	Typically 175 cpm/µR/hr (^{137}Cs gamma)	Typically 900 cpm/µR/hr (^{137}Cs gamma)	Typically 66 cpm/µR/hr (^{137}Cs gamma)
TUBE	1.5"(3.8cm) diameter magnetically shielded photomultiplier	2"(5.1cm) diameter magnetically shielded photomultiplier	0.5"(1.3cm) diameter magnetically shielded photomultiplier
DYNODE STRING RESISTANCE	100 megohm	60 megohm	100 megohm
SIZE	2"(5.1cm) diameter 7.3"(18.5cm)L	2.6"(6.6cm) diameter 11"(27.9cm)L	0.9"(2.3cm) diameter 7.8"(19.7cm)L
WEIGHT	1 lbs (0.5kg)	2.3 lb (1.1kg)	0.3 lbs (0.1kg)

Floor Monitor

Model 239-1F

FLOOR MONITOR



Note: This unit includes a two stage regulator and flow meter .
(Pictured gas bottle not included. Contact your local gas distributor for bottle.)

Specifications

INDICATED USE: Floor Monitoring for Alpha, Beta-Gamma
DETECTOR: Gas proportional
RECOMMENDED COUNTING GAS: P-10 (*10% methane; 90% argon*)
BOTTLE SIZE: Typically used with Matheson size 2 or Linde Q
WINDOW: 0.8 mg/cm^2 aluminized mylar (*window thicknesses of 0.4, 3.9, or 7.9 mg/cm^2 are available*)
ACTIVE AREA: Approximately 582 cm^2
OPEN AREA: Approximately 425 cm^2
EFFICIENCY (4pi geometry): Typically 17%-^{239}Pu; 25%-^{90}Sr/^{90}Y; gamma - less than 1%
GAS RECHARGE: Will operate on static charge for over 2 hours
COMPATIBLE INSTRUMENTS: Typically used with Model 12, 2221, 2224, or 2350-1
DETECTOR HEIGHT: Adjustable from 0.125" (0.32cm) - 3" (7.6cm) from surface
DETECTOR OPERATING VOLTAGE:
Alpha: Typically 1000 - 1200 volts
Beta-gamma: Typically 1600 - 1800 volts
THRESHOLD: Typically 2 - 4mV
FLOW METER: IN - Adjustable from 0 - 100 cc/min
OUT - Flow indicator from 0 - 100 cc/min
GAS CONNECTORS: Double end quick disconnect for 0.25" (0.6cm) OD tubing
GAS CONSUMPTION: Typically 50 cc/min
CONSTRUCTION
DETECTOR: Anodized aluminum housing with stainless steel hex protective screen (*79% open*)
CART: 1" square tubular steel and aluminum with beige polyurethane enamel paint, 7.5"(19.1cm) diameter rear wheels, and 4" (10.2cm) diameter swivel casters
SIZE
DETECTOR: 0.8" (2cm)H X 6.3" (16cm)W X 18.3" (46.5cm)L
CART ASSEMBLY: 42" (106.7cm)H X 16" (40.6cm)W X 27.5" (69.9cm)L (excluding detector)
WEIGHT: 25 lbs (11.4kg), excluding gas bottle and counting instrument

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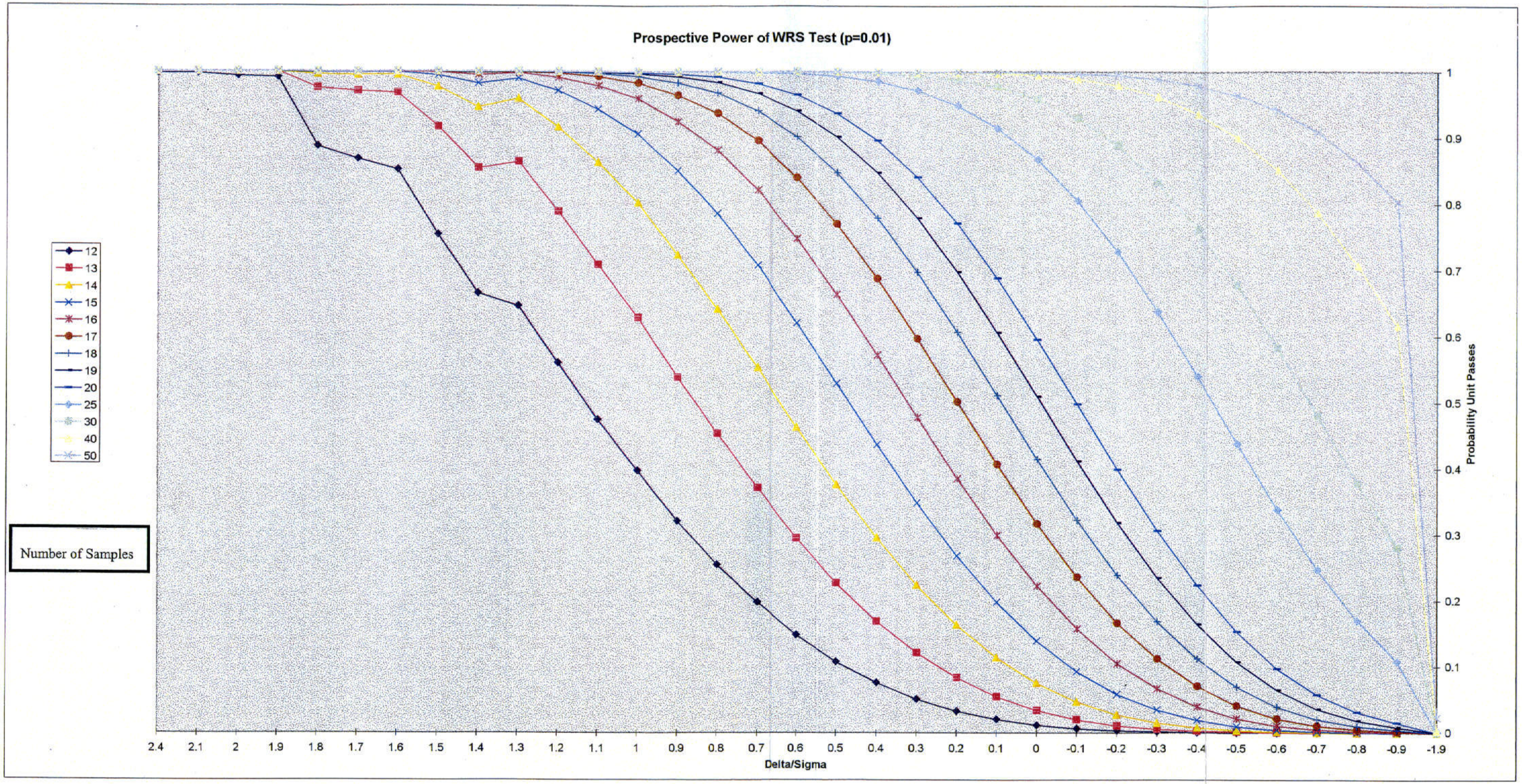
MARSSIM Excerpts

Table 3.3 Number of Samples, $N/2$, Required in Both Reference Area and Survey Unit to Meet Error Rates α and β With Relative Shift Δ/σ, When Using the Wilcoxon Rank Sum Test

	α = 0.01				α = 0.05				α = 0.10				α = 0.25			
	β				β				β				β			
Δ/σ	0.01	0.05	0.10	0.25	0.01	0.05	0.10	0.25	0.01	0.05	0.10	0.25	0.01	0.05	0.10	0.25
0.1	5452	3972	3278	2268	3972	2726	2157	1355	3278	2157	1655	964	2268	1355	964	459
0.2	1370	998	824	570	998	685	542	341	824	542	416	243	570	341	243	116
0.3	614	448	370	256	448	307	243	153	370	243	187	109	256	153	109	52
0.4	350	255	211	146	255	175	139	87	211	139	106	62	146	87	62	30
0.5	227	166	137	95	166	114	90	57	137	90	69	41	95	57	41	20
0.6	161	117	97	67	117	81	64	40	97	64	49	29	67	40	29	14
0.7	121	88	73	51	88	61	48	30	73	48	37	22	51	30	22	11
0.8	95	69	57	40	69	48	38	24	57	38	29	17	40	24	17	8
0.9	77	56	47	32	56	39	31	20	47	31	24	14	32	20	14	7
1.0	64	47	39	27	47	32	26	16	39	26	20	12	27	16	12	6
1.1	55	40	33	23	40	28	22	14	33	22	17	10	23	14	10	5
1.2	48	35	29	20	35	24	19	12	29	19	15	9	20	12	9	4
1.3	43	31	26	18	31	22	17	11	26	17	13	8	18	11	8	4
1.4	38	28	23	16	28	19	15	10	23	15	12	7	16	10	7	4
1.5	35	25	21	15	25	18	14	9	21	14	11	7	15	9	7	3
1.6	32	23	19	14	23	16	13	8	19	13	10	6	14	8	6	3
1.7	30	22	18	13	22	15	12	8	18	12	9	6	13	8	6	3
1.8	28	20	17	12	20	14	11	7	17	11	9	5	12	7	5	3
1.9	26	19	16	11	19	13	11	7	16	11	8	5	11	7	5	3
2.0	25	18	15	11	18	13	10	7	15	10	8	5	11	7	5	3
2.25	22	16	14	10	16	11	9	6	14	9	7	4	10	6	4	2
2.5	21	15	13	9	15	11	9	6	13	9	7	4	9	6	4	2
2.75	20	15	12	9	15	10	8	5	12	8	6	4	9	5	4	2
3.0	19	14	12	8	14	10	8	5	12	8	6	4	8	5	4	2
3.5	18	13	11	8	13	9	8	5	11	8	6	4	8	5	4	2
4.0	18	13	11	8	13	9	7	5	11	7	6	4	8	5	4	2

The width of the gray region, Δ, is a parameter that is central to the nonparametric tests discussed in this report. It is also referred to as the *shift*. In this report, the gray region is always bounded from above by the $DCGL_W$ corresponding to the release criterion. The *Lower Boundary of the*



NAS ALAMEDA, CALIFORNIA
Figure Appendix D Operating Characteristic Curve for Wilcoxon Rank Sum Test Prospective Power for Varying Sample Sizes
Engineering Field Activity West

APPENDIX E

STATEMENT OF WORK FOR LABORATORY

STATEMENT OF WORK

RADIOCHEMICAL ANALYSIS OF WATER, SOIL, AND SWIPE SAMPLES

May 19, 1998

Prime Contractor	:	**Tetra Tech EM Inc.** **San Francisco Office**
Technical Contact	:	**Leslie Neudert**
Client	:	**Department of Navy** **Naval Facilities Engineering Command, Engineering Field Activity West**
Prime Contract No.	:	**N62474-94-D-7609**
Project No.	:	**069-147**
Project Title	:	**Radiochemical Analysis of Water, Soil, and Swipe Samples**
Site Name	:	**Alameda Point, Alameda, California**
Solicitation Number	:	**XXXXXXXXXXXXX**
Subcontract Term	:	**June 1, 1998 through October 31, 1998**

A. INTRODUCTION

Tetra Tech EM Inc. (TtEMI) has received Contract Task Order No. 147 from the Department of Navy Naval Facilities Engineering Command, Engineering Field Activity West (EFA West) under Comprehensive Long-Term Environmental Action Navy (CLEAN II) contract No. N62474-94-D-7609 to perform a radiological removal action at Installation Restoration (IR) Sites 1, 2, 5, and 10 at Alameda Point, located in Alameda, California, as part of remedial investigation/feasibility study (RI/FS) activities.

In support of this effort, TtEMI requires a subcontractor to perform radiochemical analysis on soil, water, and swipe samples collected from various locations on Alameda Point. The study is part of the radiological removal action at Alameda Point. The analytical results will be used to determine the amounts of soil to excavate, as well as other activities to be conducted. This statement of work (SOW) presents the analytical requirements that will promote high quality laboratory data which meets the data quality objectives of the project.

The project will require the analysis of 200- samples. The number of samples of each matrix is anticipated to be 75 soil samples, 25 water samples and 100 swipe samples. Field sampling is scheduled to occur between June 15, 1998 and October 31, 1998. TtEMI is anticipating the collection and submittal of up to 30 samples per week. Additional samples may be submitted to the successful bidder, however sample quantities are not known at this time. All samples are to be retained at least 6 months.

B. SUBCONTRACTOR QUALIFICATIONS

To be considered for this subcontract, the subcontractor's laboratory practices and procedures shall meet contract laboratory program (CLP) level 5 requirements for alpha and gamma spectrographic analysis and United States Environmental Protection Agency (EPA) Method 900.0 for gross alpha and gross beta. Furthermore, the subcontractor shall demonstrate its technical capability in the area of certifications and approval, and resources, including personnel and equipment. The subcontractor shall supply to TtEMI a copy of its standard operating procedures (SOP) titles, method summaries and EPA method number cross-references for all analysis performed with its proposal along with a sample data package for gamma spectroscopy.

The subcontractor shall be regularly participating in at least one United States Department of Energy (DOE), or other national quality assurance (QA)/cross check program to perform radiochemistry analysis for each of the required analytes. The subcontractor shall demonstrate the highest level of quality and experience for this project and shall have demonstrable experience providing contract level program (CLP) services. The subcontractor shall report analytical results in a CLP type or Level 4 data package. In addition, the subcontractor shall provide to TtEMI a copy of the EPA and DOE QA/cross check results for the past four years with its proposal.

Problem Resolution

The subcontractor shall immediately notify the TtEMI technical and subcontract representatives of any problems or laboratory conditions that may adversely affect the quality and/or timeliness of analysis and data reporting. Notification and resolution of any problems shall be done prior to further sample analysis. The subcontractor shall operate at its own risk if problems occur and analysis continues without approval from the TtEMI subcontract and technical representatives. Furthermore, the subcontractor shall have one calendar week from receipt of a request for information to respond to any additional concerns of TtEMI.

Resources

The subcontractor shall exert its best efforts to provide qualified personnel and appropriate analytical equipment needed to support all the requirements of the subcontract. The subcontractor shall retain a staff that possesses analytical, technical expertise in (1) radiochemical analysis; (2) quality assurance/quality control (QA/QC) procedures; and (3) operation and maintenance of the laboratory information management system. The subcontractor shall, at all times, have sufficient qualified personnel and appropriate analytical instrumentation available to meet technical and contractual requirements of each analysis that it performs.

C. TASKS

For this sampling event, TtEMI will require the subcontractor to conduct the following: (1) gamma spectroscopy, (2) alpha spectroscopy, and (3) gross alpha/gross beta analysis.

Task 1 Gamma Spectroscopy

This section presents specific requirements the subcontractor shall meet for radioisotopes analyzed by high resolution gamma spectrometry. Documentation associated with each of the following items should be provided by the subcontractor as part of the data package.

Case Narrative

A case narrative shall be included with each data package. Abnormalities encountered with the samples, matrix problems, reanalysis, and deviations from the referenced analytical method shall be highlighted.

Instrument Calibration

The following subsections identify the minimum criteria for initial calibration, continuing calibration, and background counts.

Initial Calibration

Initial instrumentation calibration shall meet the following criteria:

- Each detector used shall be calibrated prior to and within one year of the sample analysis dates within the energy range of approximately 25 to 2,000 Kilo electron volts (KeV).
- Coefficients of the energy calibration and efficiencies for each target nuclide shall be provided with each data package.
- Initial calibration standards shall be National Institute of Standards Technology (NIST)-traceable, and certificates and a dilution log shall be provided.
- Detector resolution at the cobalt-60 photopeak of 1332 KeV shall be at least 3.0 KeV full width at half maximum (FWHM) or less.

Continuing Calibration

The following continuing instrument calibration criteria shall be met:

- Calibration check standards shall be counted at least weekly in each detector used for sample analysis, and the results shall be submitted with the data package.
- NIST certificates for the check standards and dilution log shall be submitted with the data package.
- Calibration check system gain, FWHM, and efficiency shall be within the laboratory control limits.

Background Counts

- The subcontractor's instrument background counts shall meet the following criteria
- Background counts shall be performed at least monthly on each detector used for sample analyses for a duration similar to the sample counts.
- Background counts including a spectral summary shall be provided in each data package for each detector and geometry used for sample analysis.

Blanks

The subcontractor's laboratory blank analysis shall meet the following criteria:

- Laboratory blank analysis shall be performed at a 5% frequency (1 in 20 samples) for the same matrix or at least once per sample delivery group (SDG).
- Laboratory blanks shall be prepared at the same time as and analyzed with the samples using the sample procedure, aliquot size, geometry, and counting time.
- Results for laboratory blanks shall be less than or equal to the minimum detectable activity (MDA) and contract required detection limit (CRDL).

If these criteria are not met, the laboratory shall reanalyze the method blanks. The laboratory shall provide the following information relating to laboratory blank data:

- Raw data including identification, count duration, geometry, gross and background counts
- Checks on results and MDA values

Laboratory Control and Blank Spike Samples

Laboratory control samples (LCS) or blank spike samples (BSS) evaluated shall meet the following criteria:

- Analyses shall be performed at a 5 percent frequency (1 in 20) for the same matrix or at least once per SDG.

- Samples shall be prepared at the same time as and analyzed with the associated samples in the same geometry, count duration, and aliquot size.
- LCS or BSS activity shall not exceed 1000 Pico-Curies (pCi) total activity or shall not be greater than 5 to 50 times the total sample activities.
- The actual LCS concentration or the spike concentration including traceability and a dilution log shall be provided.
- Results shall be within the limits of 80 percent to 120 percent recovery.

If these criteria are not met, the laboratory shall reanalyze the LCS or BSS.

Laboratory Duplicates

The subcontractor shall perform laboratory duplicate analysis as follows:

- Duplicate analysis shall be performed at a 5 percent frequency (1 in 20) for each matrix in each analytical batch or at least once per SDG.
- Duplicate samples shall be prepared at the same time as and analyzed with the associated samples in the same analytical run, using the same geometry, aliquot size, and count duration.
- The relative percent difference (RPD) must be less than 35 percent for soil samples and must be less than 20 percent for water samples if the sample concentration is greater than 5 times the CRDL.
- For samples results less than 5 times the CRDL, the difference between the primary and duplicate sample results must be less than two times the CRDL for soil samples.

Sample Results Quantitation and Minimum Detectable Activities

The laboratory shall report the following information for each sample:

- TtEMI sample identification information
- Laboratory sample identification, batch numbers, geometry numbers
- Date and time of sample, blank, LCS or BSS, and duplicate analyses
- Detector identification, geometry, energy, efficiency, and FWHM coefficients

- Sample and background net counts
- Printouts of region of interest channel counts
- count duration
- Calculated sample activities, uncertainties, and MDA values
- Sample volumes
- Required detection limits

The minimum detectable activity (MDA) is derived in the appendix, and values for gamma spectroscopy are shown in Table 1, which follows the text of this SOW.

Task 2 Alpha Spectroscopy

This section presents specific requirements for isotopic analysis of uranium radioisotopes using alpha spectroscopy. Documentation associated with each of the following areas should be provided with the results.

Case Narrative

A case narrative shall be included with each data package. Abnormalities encountered with the samples, matrix problems, reanalysis, and deviations from the referenced analytical method should be highlighted.

Initial Calibration

Initial instrument calibration shall meet the following criteria at a minimum:

- Each detector used shall be calibrated prior to and within 1 year of the sample analysis dates.
- The detectors shall be demonstrably calibrated in the appropriate energy range.

- Calibration standards shall be National Institute of Standards and Testing (NIST) -traceable, and certificates shall be provided.

The following raw data will be provided:

- Detector identification, energy calibration curves, calibration dates, planchet weights, peak counts and detector efficiency, and background counts for each counting system used for sample analysis
- NIST traceability certificates for all calibration standards, including a dilution log documenting the preparation, radionuclide, lot numbers, and disintegration per minute (DPM) activity

Continuing Calibration

The following continuing instrument calibration criteria shall be met:

- Background counts shall be performed at least weekly on the detector used for sample analysis.
- Detector source check counts shall be performed daily.
- The following raw data shall be provided by the subcontractor: continuing calibration results, detector information, source and background counts, quality control charts, date of preparation, activity, NIST certificates, and dilution log.

Background Counts

The instrument background shall meet the following criteria:

- Background counts shall be performed no more often than weekly and prior to sample analysis for each sample delivery group (SDG).
- Background counts shall be within the established laboratory control limits.

Blanks

Laboratory blank analysis should meet the following criteria:

- Performance at a 5 percent frequency (1 in 20) for the sample matrix or at least once per SDG

- Preparation at the same time as and analysis with the samples using the same procedure, aliquot size, and counting time
- Results that are less than or equal to the MDA and contract-required detection limit (CRDL), if specified

If these criteria are not met, the laboratory shall reanalyze the method blanks. The laboratory shall provide, in a data package submitted to TtEMI, the following information relating to laboratory blank data:

- Raw data, including detector identification, count duration, and gross and background counts
- Checks on results and MDA values

Laboratory Control and Blank Spike Samples

Laboratory control samples (LCS) or blank spikes samples (BSS) evaluated shall meet the following criteria:

- LCS or BSS analysis shall be performed at a 5 percent frequency (1 in 20) for the same matrix or at least once per SDG.
- LCS samples shall be prepared from NIST-traceable material.
- LCS or BSS shall be prepared at the same time as and analyzed with the associated samples in the same analytical run using the same procedure.
- Results shall be between 5 and 30 times the associated MDA values.
- The actual LCS concentration or the spike concentration and the amount of spike added for the BSS shall be identified.
- Results shall be within the limits of 70 to 130 percent recovery.

If these criteria are not met, the laboratory shall reanalyze the LCS and BSS.

Tracer Recovery

The laboratory shall provide the following information and meet the stated criteria for tracer recovery:

- Each sample shall be spiked with an appropriate tracer, as applicable for the analytical method.
- Tracer activity, NIST-traceability of the tracer material, and a dilution log shall be provided.
- Raw data shall be provided showing the amount of tracer added and the gross counts per minute of the tracer.
- Tracer recovery shall be within the limits of 50 to 110 percent.

If these criteria are not met, the laboratory shall repeat tracer recovery.

Matrix Spike Samples

Matrix spike sample analysis shall be performed as follows.

- Matrix spike sample analysis shall be performed at a 5 percent frequency (1 in 20 samples) for the same matrix or least once per SDG.
- Matrix spike samples shall be prepared at the same time as and analyzed with the associated samples in the same analytical run, using the same procedure.
- Percent recovery shall be within the limits of 75 to 125 percent unless sample concentration exceeds the spike concentration by a factor of 4 or more.

Laboratory Duplicates

Laboratory duplicate analysis shall be performed as follows:

- Laboratory duplicate analysis shall be performed at a 5 percent frequency (1 in 20 samples) for each matrix in each analytical batch or at least once per SDG.
- Laboratory duplicate samples shall be prepared at the same time as and analyzed with the associated samples in the same analytical run, using the same procedure.

- The relative percent difference (RPD) must be less than 20 percent for water samples if the sample concentration is greater than 5 times the CRDL.
- For sample results that are less than 5 times the CRDL, the difference between the primary and duplicate sample results must be less than 2 times the CRDL for soil results.

Spectroscopy Performance

The laboratory shall establish spectroscopy performance parameters and maintain them within acceptable tolerance parameters. At a minimum, full width at half maximum (FWHM), net counts under each peak monitored, and background must be monitored with control charts.

Sample Result Quantitation and Minimum Detectable Activities

The laboratory shall report the following information for each sample:

- TtEMI sample identification
- Laboratory sample identification
- Date and time of sample, blank, LCS or BSS, and duplicate analyses
- Detector identification and efficiency
- Holding times
- Method blank result
- Sample spectra showing peak integration parameters and FWHM
- Sample and background counts
- Count duration
- Planchet weights
- Sample volume
- Tracer recovery counts
- Background counts (weekly)
- Calculated sample activities uncertainties, and MDA values

- Required detection limits
- Decay correction factors applied (if any)

The minimum detectable activity (MDA) is derived in the appendix, and values for alpha spectroscopy are shown in Table 3, which follows the text of this SOW.

Task 3 Gross Alpha and Gross Beta Analysis

This section presents specific requirements for gross alpha and gross beta analyzed by gas proportional counters. Documentation associated with each of the following areas should be provided to TtEMI, in accordance with commercial practice (non-CLP).

Case Narrative

A case narrative shall be included with each data package. Abnormalities encountered with the samples, matrix problems, reanalysis, and deviations from the referenced analytical method should be highlighted.

Instrumentation Calibration

The following subsections identify the minimum criteria for initial calibration, continuing calibration, and background counts.

Initial Calibration

Initial instrumentation calibration shall meet the following criteria.

- Each detector used shall be calibrated prior to and within 1 year of the sample analysis dates.
- Initial calibration standards shall be NIST-traceable, and certificates and a dilution log shall be provided.

The following raw data shall be provided:

- Detector identification, self-absorption curves, calibration dates, planchet weights, raw and background counts for each counting system used for sample analysis

- NIST traceability certificates for all calibration standards including a dilution log documenting the preparation, radionuclide, lot numbers, and DPM activity

Continuing Calibration

The following continuing instrument calibration criteria shall be met:

- Background counts shall be performed at least weekly on the detector used for sample analysis.

- The following raw data shall be provided: continuing calibration results, detector information, source and background counts, date of preparation, activity, NIST certificates and dilution log.

Background Counts

The instrument background shall meet the following criteria:

- Background counts shall be performed weekly and prior to sample analysis.

- Background counts shall be within the laboratory control limits.

Sample Result Quantitation And Minimum Detectable Activities

The minimum detectable activity (MDA) is derived in the appendix, and values for alpha and beta proportional counting are shown in Table 2, which follows the text of this SOW.

The laboratory will report results and backup information consistent with commercial practice.

D. SAMPLE MEDIA SPECIFIC REQUIREMENTS

Water

The laboratory shall supply suitable containers for the number of samples requested including extra containers for trip blanks, field blanks, and possible breakage, preservative in ampoules, and sampling details (minimum volume required, preservation requirements).

Soil

The laboratory shall supply suitable containers for the number of samples requested including extra containers for trip blanks, field blanks, and possible breakage, and sampling details (minimum volume required).

Swipe

The laboratory shall supply suitable rugged paper or cloth swipes for proportional counting with individual swipe folders.

E. DELIVERABLES

An electronic data deliverable is required for this project. The subcontractor laboratory shall provide, 15 days after sample receipt, two copies of all analytical data in hard copy form and one electronic copy of summary information in the format specified in this CTO. Electronic data shall be provided on 3.5-inch high-density diskette in IBM PC compatible format in fixed field length, comma delimited, or Microsoft Excel (*.xls) format. The hard copy data shall be submitted concurrently with the electronic data. Partial submittals are unacceptable.

Routine turnaround time shall be 10 days from sample receipt to preliminary results. Rush turnaround time for samples received by 6:00 PM shall be overnight, with preliminary results sent by facsimile by 9:30 am. Final data packages shall be delivered within 15 days of sample receipt.

The subcontractor shall provide a comprehensive written summary of the data package, explaining all relevant terms and showing all calculation methodologies used, for each analysis for the first sample group only.

The subcontractor shall provide one copy for each analysis of the EPA method used and the laboratory SOP used and one copy of the laboratory quality assurance plan with the first sample group only.

The subcontractor shall include a written description of the electronic file format with the diskette. The subcontractor shall verify that the electronic deliverable matches the results and data presented in the hard copy report.

The electronic file shall contain at least the following fields:

- Field sample number
- Sample media
- Sample volume received
- Sample receipt problem or problem code
- Laboratory assigned sample number
- Sample received date
- Laboratory identifier
- Method identifier
- Analyte
- Associated blank identifier
- Sample delivery group
- Analysis date
- Sample activity
- Counting uncertainty
- Total propagated uncertainty

- Detection limit (MDA)
- Required detection limit
- Special identifier (for duplicates, matrix spikes, matrix spike duplicates, blanks, and laboratory control samples
- Laboratory validation code
- Tasks and deliverables schedule
- Quality

F. WASTE DISPOSAL

Subcontractor shall be responsible for disposal of all samples.

TABLE 1

REQUIRED MAXIMUM RADIOCHEMISTRY ANALYTICAL DETECTION LIMITS SOIL AND WATER

Isotope	Matrix	Analytical method	Method[1]	MDA[2]
Radium-226	water	gamma spectrometry	EPA-901.1	10 pCi/liter
Radium-226	soil	gamma spectrometry	EPA-901.1	2 pCi/gram

TABLE 2

REQUIRED MAXIMUM ANALYTICAL DETECTION LIMITS FOR SWIPES

Isotope	Matrix	Analytical method	Method	MDA (dpm/100 cm^{2}) (swipe)
Ra-226	swipe	gamma spectrometry	EPA 901.1	10
gross alpha	swipe	proportional counter	EPA 900.0	5
gross beta	swipe	proportional counter	EPA 900.0	50

TABLE 3

REQUIRED MAXIMUM ANALYTICAL DETECTION LIMITS FOR ISOTOPIC URANIUM

Isotope	Matrix	Analytical method	Method	MDA (pCi/g)
U-235	soil	alpha spectrometry	907	0.025
U-238	soil	alpha spectrometry	907	0.25

1 Prescribed Procedures for the Measurement of Radioactivity in Drinking Water, EPA-600/4-80-032.

2 MDA is for method blank. Detection limits may be higher in the presence of significant activity of other radioisotopes.

APPENDIX

Maximum attained *(a posteriori)* detection limits required for the project are defined in tables one through three. Detection limits shall be computed at the 95th percentile confidence interval and shall represent the activity for which the laboratory can correctly identify the analyte as different from background considering total propagated errors (counting uncertainty and other errors associated with the analysis). The laboratory shall report the actual measured activity based on the net count, including those results below the decision limit or critical level.

The detection limit is normally given by:

$$L_c = k\sqrt{2} \times \sqrt{B}$$
$$L_d = k^2 + 2\,L_c$$

where:

k = 1.645, the value of the standard normal deviate that is exceeded 5 percent of the time
B = the background count
L_c = the critical level or decision limit, and
L_d = the detection limit

The minimum detectable activity (MDA) or lower limit of detection (LLD) in activity per unit mass (or volume) is given by the general form of:

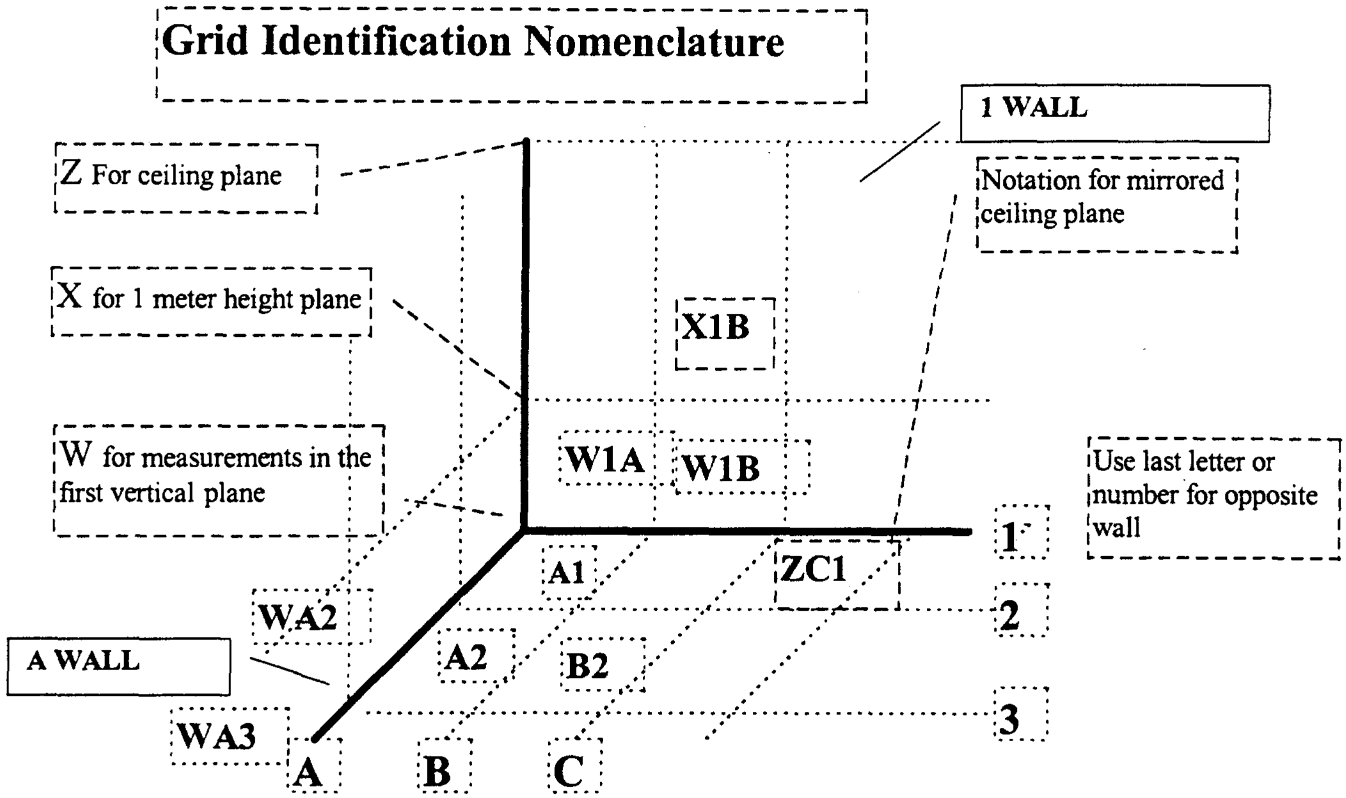
$$MDA(LLD) = \frac{L_d}{VYET}$$

where:

V = sample volume
Y = chemical yield
E = detector efficiency
T = counting time

APPENDIX F

GRID IDENTIFICATION NOMENCLATURE


Grid Identification Nomenclature
Z For ceiling plane
1 WALL
Notation for mirrored ceiling plane
X for 1 meter height plane
X1B
W for measurements in the first vertical plane
W1A
W1B
Use last letter or number for opposite wall
1
A1
ZC1
WA2
2
A WALL
A2
B2
3
WA3
A
B
C

Radiation Survey Map

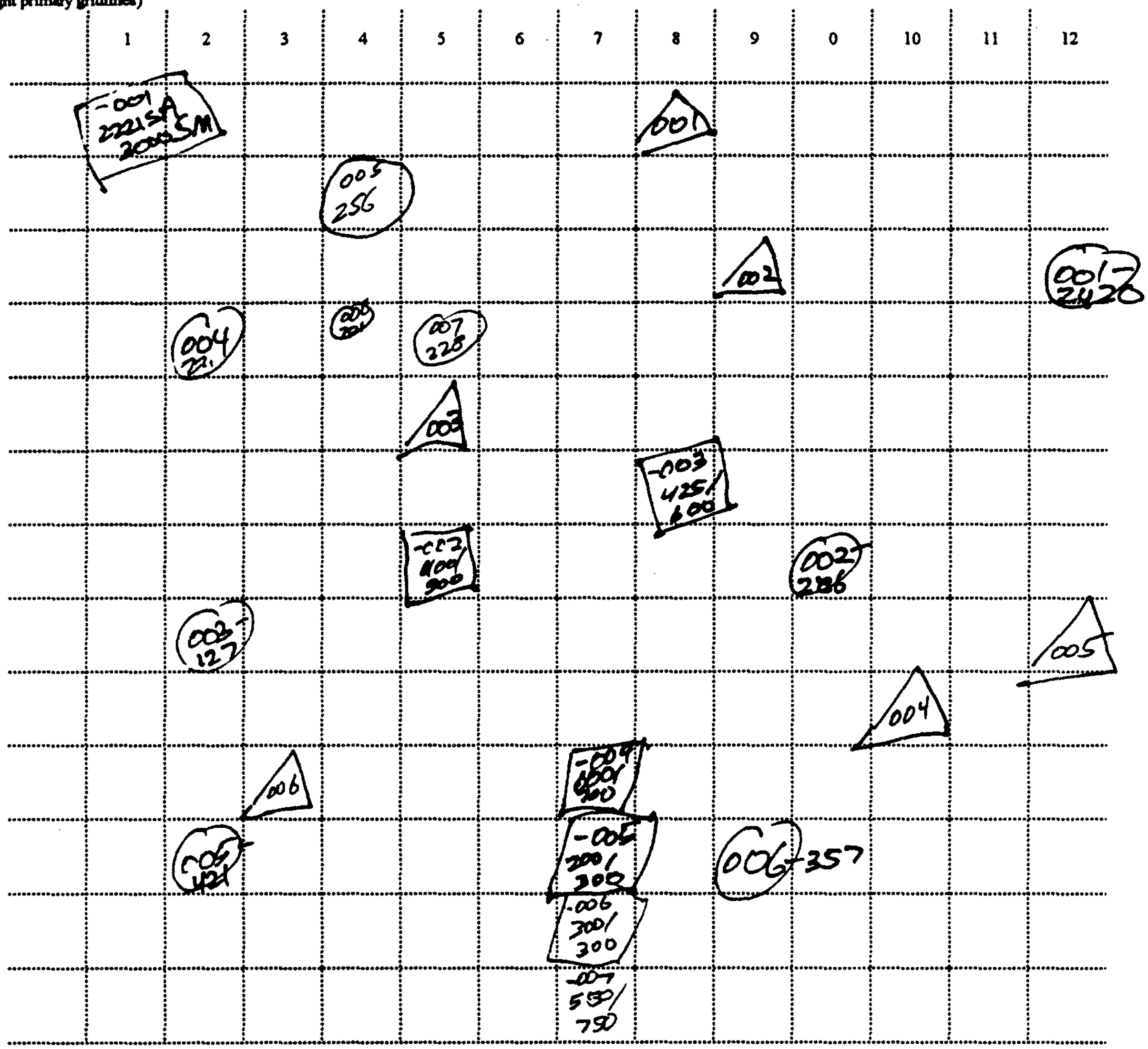
CTO ________ Site/Task ________ Surveyor ________ Employee No. ________ Employer ________ Survey Date: ________

Instrument ________ Calibration No. AX Check Source No. ______ Response ______ Background ________ Background Time ______

Additional Set Up Notes: AX0122-S345-001 AX0122S346-001 S3470(

SCANS Swipes FIRED

Grid Sketch (highlight primary gridlines)



Notes: Sample

Completed By: ________ Sign ________ Date ________

Reviewed By: ________ Sign ________ Date ________

Validation

SAMPLE

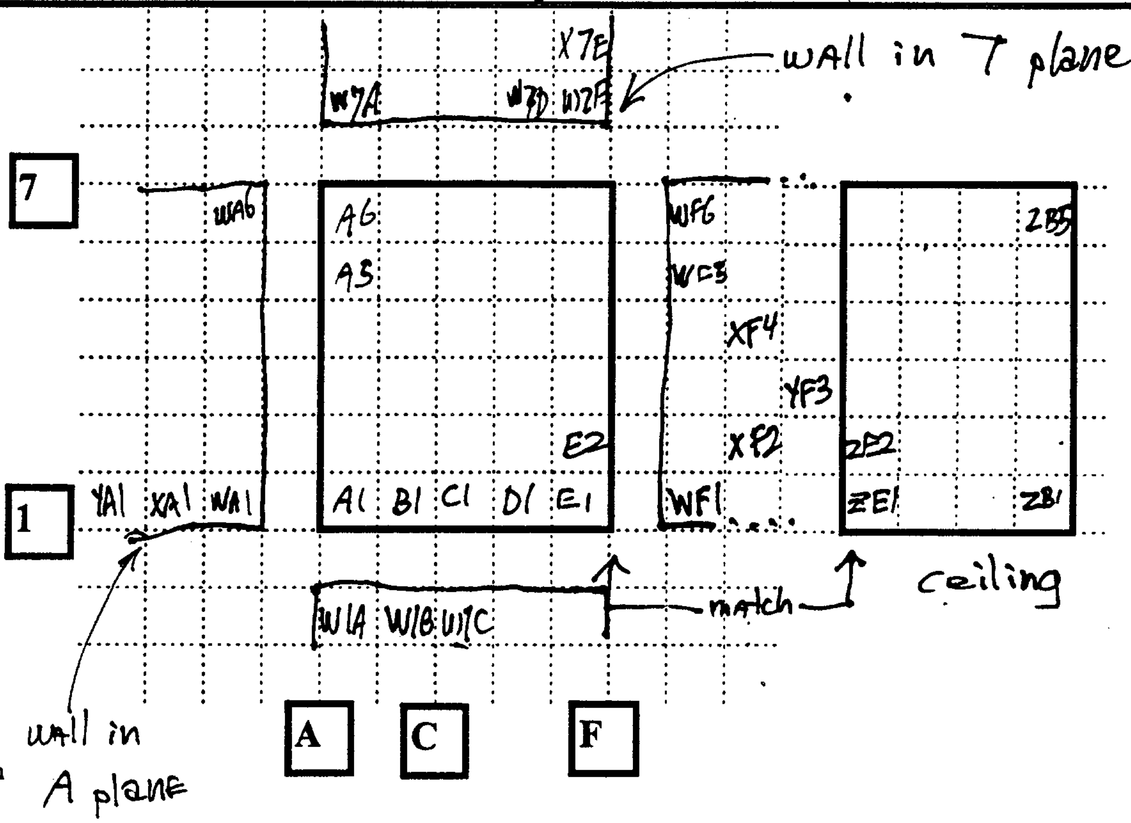
Radiation Survey Map

CTO 022 Site/Task Alameda Surveyor ABS Employee No. ________ Employer TTEM Survey Date: ________

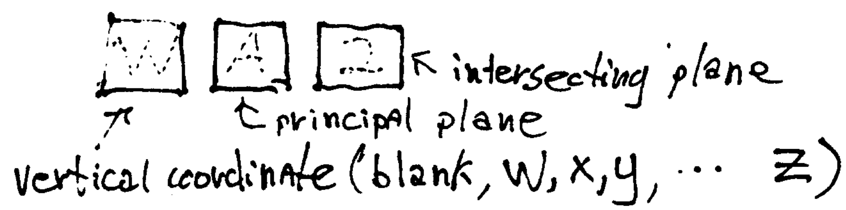
trument ________ Calibration No. ______ Check Source No. _____ Response ______ Background ___ Background Time ______

Additional Set Up Notes: to illustrate grid identification nomenclature

Sketch



Sample uniform grid numbering



Notes: Floor & ceiling coordinates should mirror
Z is always ceiling
blank is always floor

Completed By: ________ Sign ________ Date ________

Reviewed By: ________ Sign ________ Date ________

ion ________

APPENDIX G

RADIATION SURVEY DATA FILE SPECIFICATION

APPENDIX G

RADIATION SURVEY DATA FILE SPECIFICATION

The radiation survey subcontractor shall submit radiation survey data in the format specified in Exhibit 1. Survey data format consists of a number of tables (spreadsheets or files) linked by unique codes specified by the data generator. The tables, recommended file names, field names, and field descriptions are provided in the exhibit. Any deviations should be reviewed with the contractor technical representative first. Laboratory radioanalytical data may be submitted in another format after it is approved by the contractor technical representative. The subcontractor is responsible for adding any additional fields necessary to properly transmit complete data to the contractor.

Data shall be provided in IBM PC™ compatible format on 3.5-inch floppy diskettes. Data format shall be ASCII (DOS) or Windows format. File type shall be Excel™ (version 3,4 or 5), Access™, database (dbf), or text (tab delimited format).

APPENDIX G

Exhibit 1

DATA REPORTING FORMAT
RADIATION SURVEY DATA

Table Name: **Surveyor file name: surv_nam**

FIELD NAME	DATA TYPE	DATA FORMAT	SPECIAL	DESCRIPTION
initials	code	text	unique	initials of individual calibrating or measuring
last	data	text	required	
first	data	text	required	
middle	data	text	required	
employee number/ssn	data	text		
employer code	data	text	match, required	

Table Name: **Entity File name : Entity**

FIELD NAME	DATA TYPE	DATA FORMAT	SPECIAL	DESCRIPTION
entity name	data	text		Entity legal name
entity code	data	text	unique	four-character code in the format x-nn where x is the entity type code and nn is a unique code for the entity
entity type	code	text	required	type code: laboratory (L), employer (E), instrument manufacturer (I), source manufacturer (S), other (O), Subcontractor (C)
technical contact	data	text	optional	name of a technical contact for questions
financial contact	data	text	optional	name of a financial contact for questions
address1	data	text	required	
address2	data	text	required	
city	data	text	required	
state	data	text	required	
zip	data	text	required	
phone	data	text	required	
fax	data	text	required	

APPENDIX G

Exhibit 1

Table Name: **Source information file name: sourc_in**

FIELD NAME	DATA TYPE	DATA FORMAT	SPECIAL	DESCRIPTION
source id	code	text	unique	Five character code identifying source in format A-001 (for alpha source 1, etc.)
entity code	data	text	match from entity table	s-xx
source serial	data	text		from supplier
emission	data	text		alpha,beta, etc.
isotope	data	text		
half life	data	number		in days or blank for long half-life
calibration date	data	mm/dd/yy		from source certificate
traceable	data	yes/no		to NIST
initial activity	data	number		in dpm
activity 1/1/97	data	number		
activity today	data	number	required	activity of report date or date used in calculations
correction factor		number		any special modifying factor
CF explanation		text		explanation of previous factor
time decay factor		number		.693/ t
calibration strength		number	required	value used in calculations for activity
construction		text		filter paper, electroplate, etc.

Table Name: **Project information file name: Project**

FIELD NAME	DATA TYPE	DATA FORMAT	SPECIAL	DESCRIPTION
Project Code	code	text	unique	"SMB"
Project Name	data	text		"NCS Stockton Mill Burner Radiation Profile"
Base Name	data	text		NCS Stockton
Contract Number	data	text		
CTO	data	text		
Subcontractor Name	data	number		
Subcontractor Code	data	text	match from entity table, required	

APPENDIX G

Exhibit 1

Table Name: Scalar information File Name: Scaler

FIELD NAME	DATA TYPE	DATA FORMAT	SPECIAL	DESCRIPTION
scalar code	code	text	unique	format s-nn
type	data	text	required	
model	data	text	required	
other info	data	text		
manuf code	data	text	match from entity table, required	
serial number	data	text	required	
last manuf cal.	data	date	required	

Table Name: location information File name: Loca_inf

FIELD NAME	DATA TYPE	DATA FORMAT	SPECIAL	DESCRIPTION
location code	code	text	unique	physical sample location identifier, usually sequential
building number	data	text	required	building identifier or other description
building description	data	text	required	
room number	data	text		
room description	data	text		
grid northing	data	text	required	reference to grid system used
grid easting	data	text	required	
actual northing	data	text		reference to coordinate system
actual easting	data	text		
grid reference	data	text	required	describe grid reference used, for multiple grids identify as grid A, B, etc.
actual reference	data	text		

APPENDIX G

Exhibit 1

Table Name: **field data File Name: Field_da**

FIELD NAME	DATA TYPE	DATA FORMAT	SPECIAL	DESCRIPTION
case reference	code	text	match, required	must match a case for instrument setup and calibration
field measurement number	identifier	text	unique	sequential measurement number
location code	code	text	match, required	
depth	data	number		sample measurement location in decimal feet bgs
multiple data	yes/no	text		code this field "yes" only if multiple analytical values from one data point will be provided, as in multichannel spectroscopy or mass spectrometry.
raw count	data	number		instrument reading (usually cpm)
net count	calculated	number	required	net reading
activity	calculated	number	required	activity (dpm, pci, etc.)
assigned error	calculated	number	required	at one standard deviation
less than	calculated	number		if reported as less than
percent error	data	number	required	coeff. of variation at 95th percent confidence
data notes	data	number	required	additional information
validation	data	text	required	your validation codes per report
measurement type	data	text	required	scan, fixed, swipe, etc., see notes
Surveyor initials	code	text	required	
laboratory result	yes/no	text		code this field "yes," if data are from a laboratory, not field instrument
laboratory used	data	text		
sample collected	yes/no	text		if a sample collected at location
sample type	data	text		solid, liquid, sludge, swipe, etc.
sample volume	data	text		
volume units	data	text		
Lab submitted to code	code	text	match	
Sample number assigned	data	text		your sample number, TtEMI format sample number
Analytical requested	data	text		

APPENDIX G

Exhibit 1

Table Name: field multi data File Name: F_mul_da

FIELD NAME	DATA TYPE	DATA FORMAT	SPECIAL	DESCRIPTION
field measurement number	identifier	text	match, required	sequential measurement number
channel identifier	data	text		isotope or window information
raw count	data	number		instrument reading (usually cpm)
net count	calculated	number		net reading
activity	calculated	number	required	activity
activity unit	data	text	required	activity units (dpm, pci, etc.)
assigned error	calculated	number	required	at one standard deviation
less than	calculated	number		if reported as less than
percent error	data			coeff. of variation at 95^{th} percent confidence

Table Name: detector information file name: det_inf

FIELD NAME	DATA TYPE	DATA FORMAT	SPECIAL	DESCRIPTION
detector code	data	text	unique	assign a unique five-character code for each detector (d-001)
detector system	data	text	required	detection method and other characteristics
detector manufacturer	data	text	required	
detector model	data	text	required	
detector serial number	data	text	required	
last manufacturer calibration date	date	mm/dd/yy	required	
detector area	data	number	required	active cm squared used in calculations
other detector information	date	text		

APPENDIX G

Exhibit 1

Table Name: **case information** **File Name: case_inf**

FIELD NAME	DATA TYPE	DATA FORMAT	SPECIAL	DESCRIPTION
case number	code	text	unique	
project code	code	text	match, required	
scalar code	code	text	match, required	
detector code	code	text	match, required	
calibration date	data	text	required	your last calibration date, this calibration
narrative info	data	text		addition information for this case
background count	data	number	required	counts
background count time	data	number	required	minutes
sample count time	data	number	required	minutes, for all data collected under this case
detection limit	data	number	required	units are count per minute
critical value	data	number	required	units are counts per minute
calib by	code	text	match, required	calibration performed by
source activity	data	number	required	calibration information, from source table
source count	data	number	required	calibration information
source count time	data	number	required	calibration information
cal. Background count	data	number	required	calibration information
cal. Background count time	data	number	required	calibration information
cal mod factor 1	data	number	default is 1	calibration information
cal mod factor 2	data	number	default is 1	calibration information
cal mod discussion	data	text		discuss the cal mod factors, geometry, backscatter, etc.
efficiency	data	number	required	calibration information
area factor	data	number	required	calibration information
detector area	data	number	required	calibration information, from detector table
activity conversion factor	data	number		multiplicative value to convert count data to activity data
activity reporting units	data	text		activity data units used (pci, dpm, dpm/100 cm^2, etc.)
activity detection limit	data	number		
activity critical value	data	number		
lab. detection limit	data	number		if data represent laboratory reported data
lab units	data	text		
cal source id	data		match, required	
lab data	yes/no			Code field "yes," if case represents a laboratory measurement

APPENDIX G

Exhibit 1

lab code	code	text	match	entity code for lab

APPENDIX G

Exhibit 1

Notes:

1. Codes designated unique are assigned by the contractor and are typically an alphanumeric (example d-01 for detector one)
2. Match indicates that the value of field must match a code assigned in a unique field
3. Data may be provided in Excel, tab delimited text (ASCII or windows), or dbf format with field headings
4. Blank descriptions are self explanatory
5. Field names may be modified; however, field orders should be retained
6. One case required for each detector Scaler combination and setup
7. Additional fields used by contractor should be added to end of table
8. A sample dataset is available from the technical representative in Excel or Access
9. Describe methods, equations, and variations from this format in report
10. For yes /no fields (yes is "yes" or -1, no is blank, 0, or "no")

- -223 is the sequence for that location
- 2986 is the count (gross)
- FA denotes a fixed count average

AREA GRIDING AND DESIGNATION

Establish 1meter-square grids in affected areas. Notate north-to-south lines A, B, etc. Notate east-to-west lines 1, 2, 3, etc. Notate vertical planes at ground W, 1 meter as X, 2 meters as Y, XA,XB, etc., and ceiling plane as Z. Contiguous rooms may use the same grid. Start a new notation for noncontiguous rooms.
Two perpendicular walls shall serve as the starting lines of reference for the starting grid lines.

The first letter is blank for the floor, and that the second letter/number is for the plan within which the wall lies. The third letter/number identifies the intersecting plane. Thus adjacent grids across a corner would be WA1 And W1A.

APPENDIX G

Exhibit 1

Field Measurement Identification

Field measurements are identified for use with an Microsoft Access™ database designed specifically for collecting data, performing necessary calculations, and reporting field measurement data. Field measurements are identified as follows. The surveyor shall start a new field data sheet for each detector calibration case and record each measurement or scan using a unique identifier that identifies the location and type of measurement. Location codes are sequential numbers developed to identify reference locations. Location codes may be assigned during the survey or established during data entry. When reporting data, code measurements as follows following the field count:

• Scan	S	S indicates maximum as SM
• Swipe	W	W denotes exactly 100 cm^2, WX may be greater area, WO indicates entire object was swiped
• Fixed Count	F	Code average count FA
• Duplicate	D	Append to type code (that is, WD, FD, SD, FAD)

Data may also be recorded directly on figures or sketches. A figure or sketch may be used to aid in location descriptions. If a series of counts are recorded on a sketch ,record the starting sequential number completely (see below) and following with the sequential/gross count result (for example, -101/2475, -102/3128, -103/2332, etc.). (The count time is identified from the reference case and count rate computed by the database) to distinguish the identifier from the count. Identify measurements on sketches as follows:

- Swipes by enclosing a sequence number in a triangle
- Fixed counts by enclosing in a circle
- Scans by enclosing the average and maximum in a square with a diagonal seperator (average/maximum)

If more than one case is recorded on a sketch, preface each reading with the unique case identifier. A typical sample may be as follows:

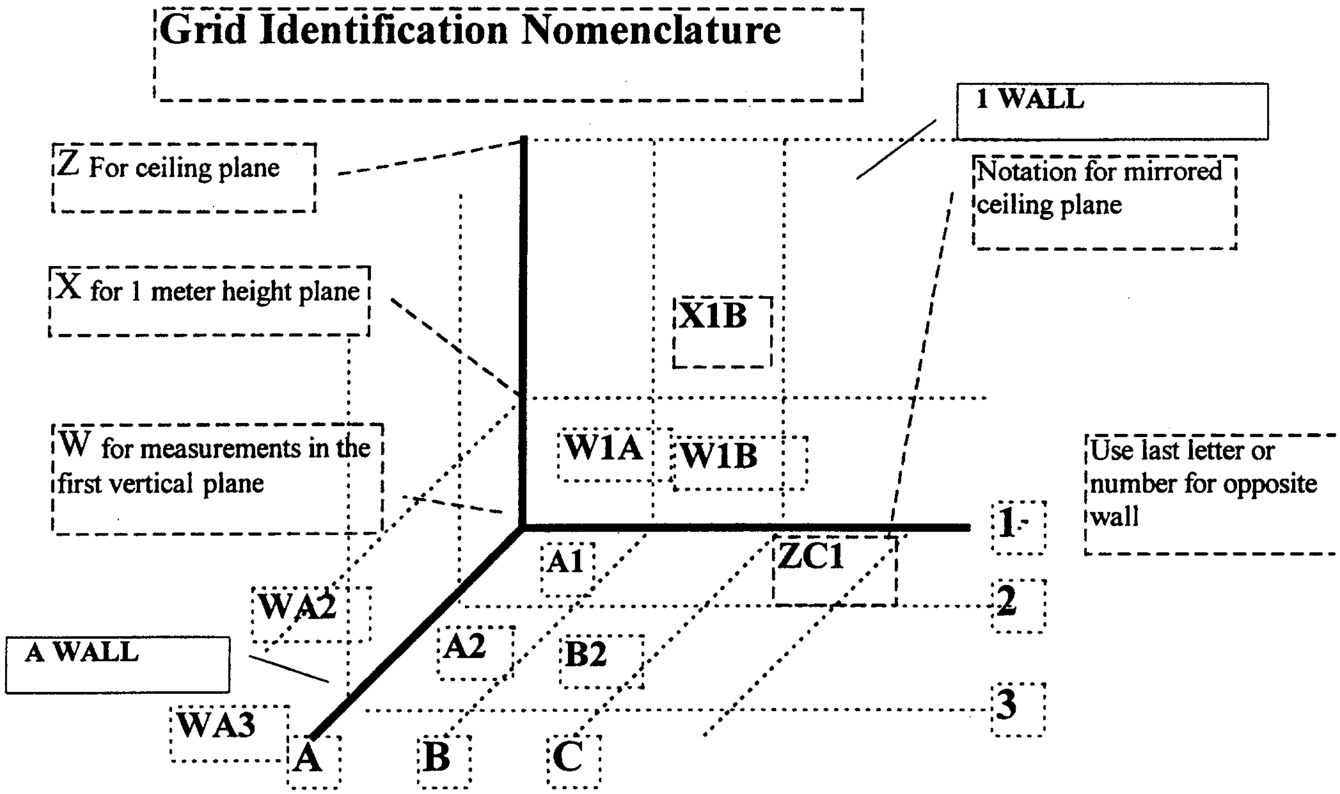
AXxxxxxx [-223/2986FA]

where:

- AX is the case
- xxxxxxxx refers to standard sample coding system

APPENDIX G

Exhibit 1



APPENDIX H

SAMPLE REPORT FORMAT FOR FIELD COUNTING

Sample Report Format for Field Counting

Bldg. No.	Calibration Set-Up Reference	ID	count	rate	net	activity	Activity sigma (95%)	report act	r max	mda	note	%error
564	a	30	**1**	1.0	0.00	0.00	3.08	< 2.6	2.58	2.6	less than ld	
564	b	30	**2**	2.0	1.00	1.11	3.77	< 4.3	4.28	4.3	less than ld	
564	b		**3**	3.0	2.00	2.22	4.36	< 5.9	5.88	5.9	less than ld	
			4	4.0	3.00	3.33	4.87	3.33 +/- 4.9	7.42	7.4	less than ld	146.1%
			5	5.0	4.00	4.44	5.33	4.44 +/- 5.3	8.92	8.9	less than ld	120.0%
			6	6.0	5.00	5.56	5.76	5.56 +/- 5.8	10.39	10.4	less than ld	103.7%
			7	7.0	6.00	6.67	6.16	6.67 +/- 6.2	11.84	11.8	less than ld	92.4%
			8	8.0	7.00	7.78	6.53	7.78 +/- 6.5	13.26	13.3	less than ld	84.0%
			9	9.0	8.00	8.89	6.89	8.89 +/- 6.9	14.67	8.2	percent error =	77.5%
			11	11.0	10.00	11.11	7.54	11.11 +/- 7.5	17.44	8.2	percent error =	67.9%
			12	12.0	11.00	12.22	7.85	12.22 +/- 7.9	18.81	8.2	percent error =	64.2%
			13	13.0	12.00	13.33	8.15	13.33 +/- 8.1	20.17	8.2	percent error =	61.1%
			20	20.0	19.00	21.11	9.98	21.11 +/- 10.0	29.49	8.2	percent error =	47.3%

C:CIS DOCUMENTS\RADIAD\TEST8 CHECK.XLS								*source activity =*		100		
			eff	factor acf				*background counts =*	10			
tb		ts	[illegible]	[illegible]				*detector counts =*	60	0.500		
100.0		2.0					*cal time(min)*	1.000	*background time =*	1		
nb		rb	area	other factor	[illegible]		lc	ld	activity lc	ald		
10.0		0.1	50.0	1	[illegible]		0.37	2.10	1.5	8.4		
				afactor	0.5							
				set area = 100 for swipes								
Bldg. No.	Calibration Set-Up Reference	ID	count	rate	net	activity	Activity sigma (95%)	report act	r max	mda	note	%error
564	a	sample 1	0.1	0.1	-0.05	-0.20	1.26	< 1.5	1.49		activity negative	
564	a	sample 2	0.6	0.3	0.15	0.60	2.78	< 2.9	2.94	2.9	less than ld	
564	a	sample 3	1	0.5	0.40	1.60	3.93	1.60 +/- 3.9	4.90	4.9	less than ld	245.5%
564	b	sample 4	2	1.0	0.90	3.60	5.55	3.60 +/- 5.5	8.26	8.3	less than ld	154.1%
564	b	sample 5	3	1.5	1.40	5.60	6.79	5.60 +/- 6.8	11.30	11.3	less than ld	121.3%
564	b	sample 6	3.1	1.6	1.45	5.80	6.91	5.80 +/- 6.9	11.60	11.6	less than ld	119.1%
564	b	sample 7	3.2	1.6	1.50	6.00	7.02	6.00 +/- 7.0	11.89	11.9	less than ld	116.9%
564	b	sample 8	3.3	1.7	1.55	6.20	7.13	6.20 +/- 7.1	12.18	12.2	less than ld	114.9%
564	b	sample 9	3.4	1.7	1.60	6.40	7.23	6.40 +/- 7.2	12.47	12.5	less than ld	113.0%
564	b	sample 10	3.6	1.8	1.65	6.60	7.34	6.60 +/- 7.3	12.76	12.8	less than ld	111.2%
565	b	sample 11	4	2.0	1.90	7.60	7.84	7.60 +/- 7.8	14.18	14.2	less than ld	103.2%
566	b	sample 12	5	2.5	2.40	9.60	8.77	9.60 +/- 8.8	16.96	8.4	percent error =	91.3%
567	b	sample 13	6	3.0	2.90	11.60	9.61	11.60 +/- 9.6	19.66	8.4	percent error =	82.8%
568	b	sample 14	7	3.5	3.40	13.60	10.37	13.60 +/- 10.4	22.31	8.4	percent error =	76.3%
569	b	sample 15	8	4.0	3.90	15.60	11.09	15.60 +/- 11.1	24.91	8.4	percent error =	71.1%
570	b	sample 16	9	4.5	4.40	17.60	11.76	17.60 +/- 11.8	27.47	8.4	percent error =	66.8%
571	b	sample 17	10	5.0	4.90	19.60	12.40	19.60 +/- 12.4	30.01	8.4	percent error =	63.3%
572	b	sample 18	11	5.5	5.40	21.60	13.00	21.60 +/- 13.0	32.51	8.4	percent error =	60.2%
573	b	sample 19	12	6.0	5.90	23.60	13.58	23.60 +/- 13.6	35.00	8.4	percent error =	57.5%
574	b	sample 20	13	6.5	6.40	25.60	14.14	25.60 +/- 14.1	37.46	8.4	percent error =	55.2%
575	b	sample 21	14	7.0	6.90	27.60	14.67	27.60 +/- 14.7	39.91	8.4	percent error =	53.1%
576	b	sample 22	20	10.0	9.90	39.60	17.53	39.60 +/- 17.5	54.31	8.4	percent error =	44.3%
577	b	sample 23	21	10.5	10.40	41.60	17.97	41.60 +/- 18.0	56.68	8.4	percent error =	43.2%
578	b	sample 24	22	11.0	10.90	43.60	18.39	43.60 +/- 18.4	59.03	8.4	percent error =	42.2%
579	b	sample 25	23	11.5	11.40	45.60	18.80	45.60 +/- 18.8	61.38	8.4	percent error =	41.2%

APPENDIX I

DETERMINATION OF RADIOACTIVITY BACKGROUND AND DETECTION LIMITS

APPENDIX I
DETERMINATION OF RADIOACTIVITY BACKGROUND AND DETECTION LIMITS

Decisions regarding background will be formulated into statistical statements called hypotheses, which are tested with survey data. Tetra Tech EM Inc. will base its statistical testing on hypothesis testing found in the U.S. Nuclear Regulatory Commission (NRC) guidance document "A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys" (NRC 1995, 1998) and MARSSIM (U.S. Environmental Protection Agency [EPA] 1997). Additional guidance was obtained from methods outlined in the "Manual for Conducting Radiological Surveys in Support of License Termination," (NRC 1992). The earlier guidance relies on a confidence interval approach, while the more recent NRC guidance relies on hypothesis testing, which is more consistent with EPA methods of statistical analysis. In addition, the hypothesis testing framework is more flexible because both Type I and Type II errors are explicitly considered. In constructing a confidence interval, only one of these errors is controlled.

For field radioactivity measurements (counting measurements), the null hypotheses (H_0) is that there is no difference between the site and background. The alternative hypothesis (H_1) is that the site is elevated above background. Statistical methods will be used to control Type I and Type II error rates. For example, more samples or longer counting times will be needed to achieve lower error rates. Specifying error rates during survey design will be used to control uncertainty and to identify acceptable levels of uncertainty.

The lower limit of detection (L_D) is the smallest amount of radioactivity that can be reliably distinguished statistically above method background for a laboratory test (Type II errors indicate false negatives, that is, a background sample value will be considered to be from within the background distribution when it is actually greater than background). The critical detection level (L_C) is the level at which there is a 5 percent chance of identifying a sample from the background population as being from a sample distribution greater than background (that is, the probability of a false positive or Type I error). This value will be used as the reporting limit when counting samples or making direct radiation measurements. Any response above this level will be considered above background (or a net positive result). The L_D is calculated to specify the level above which a 95 percent detection capability is required.. A 95 percent confidence interval (error range) will also be calculated (based on counting statistics) for all responses greater than L_D.

Background for routine field counting will be established by hypothesis testing, where the null hypothesis (H_0) that is there is no difference between background levels and site levels. The Navy CLEAN contractor will establish acceptable levels for Type I and Type II errors, and will use this information to establish L_C and L_D from field measurement of instrument response rates.

Overall, based on the approach provided above, values above L_C will be reported as above background. This will be based on hypothesis testing and associated acceptable levels of Type I and Type II errors and a 95 percent detection capability for L_D. In most cases this will correspond to a Type I error rate of 0.05 and a Type II error rate of 0.20.

MINIMUM DETECTABLE ACTIVITY

The minimum detectable activity (MDA) is calculated for each survey configuration and will be 25 to 50 percent of the guideline level. The following items describe the methodology for the determination of the MDA:

- Determination of Instrument Detection Capability. Each configuration of a detector and counting system has a unique detection capability determined by several variables. This discussion pertains to detector capability limitations based on counting statistics only.

- Definitions. The definitions relevant to a discussion of counting statistics as they pertain to field instrument detectability are outlined in the following subsections. This terminology is consistent with definitions published in the literature and applicable regulatory guidance (NRC 1995, 1998). The 95 percent confidence interval is used in all calculations. Capabilities may be reported in terms of counts and count rates or in terms converted to activity. Count data are converted to activity using a detector efficiency factor, area factor, and a term to account for errors. The correction factor is applied as a multiplier of the count data.

- Detection Level. The detection level is the *a priori* limit and represents the measurement system sensitivity. Detection level is denoted "activity L_D" and is the value stated in describing a measurement system.

- Critical Level. The critical level activity concentration (less than values) is the *a posteriori* statement of detection, which when exceeded, indicates to some desired degree of confidence that the sample is different from background.

- Reporting Data. Each measurement is reported as a net count rate and an error term or standard deviation. When the net count is below the critical level, the sample net activity is reported as less than either sample net activity plus the value of the one-sided 95 percent confidence interval; or the critical level, whichever is greater.

- Detection Limits Applied to the Field. The detection level and activity conversion factor yields the MDA in areal units with dimensions of activity per surface area. This value is used to set counting times, select detectors, and establish counting room shielding (as necessary).

- The critical level or detection limit is used in reporting field data. Critical level activity concentration values will be no greater than 50 percent of the recommended limits as presented in the guidance document "Termination of Operating Licenses for Nuclear Reactors," (U.S. Atomic Energy Commission 1974). They will typically be lower.

- Detection Levels for Scanning. Several methods for estimating scanning detection limits are in use. Detection limits for scanning are estimated from a perceptible increase in the count rate for a careful surveyor. The product of the instrument background count rate and count to activity conversion factor provides one method for estimate of the detector-specific "activity background." The detection limit is estimated as a fractional increase above that value as follows using detector slow response:

Background Count Rate (cpm)	Factor (times background)
< 5	4
5 to <30	3
30 to <50	2.5

The product of the net perceptible increase above background and the activity conversion factor provides the net detection limit.

The net limit listed is the best detection limit for a careful observer using a typical rate meter in slow response mode, holding the probe stationary, and observing meter fluctuation. The limit for a slowly moving detector is higher.

APPENDIX J

GENERAL REFERENCES/BIBLIOGRAPHY

GENERAL REFERENCES/BIBLIOGRAPHY

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ATTACHMENT 1

EPA STANDARD OPERATING PROCEDURES

SAMPLING FOR REMOVABLE RADIOLOGICAL CONTAMINATION

1.0 PURPOSE

To describe a method of obtaining samples to verify that equipment leaving a controlled area containing radioactive materials meets unrestricted release criteria for removable contamination. This equipment may include tools, vehicles, and other miscellaneous items brought in contact with radioactive materials.

2.0 DISCUSSION/APPLICATION

During the course of sampling in a radiologically contaminated area, various pieces of equipment handled by workers may become contaminated. To ensure worker safety and compliance with instrument release limits set forth in U.S. NRC Regulatory Guide 1.86, equipment must have an analysis of removable contamination performed. The standard technique for verification is to wipe a specified area (or swipe) on a piece of equipment and analyze the swipe sample for various radionuclides. Most commonly, a gross-alpha count is performed with a scintillator or proportional counter.

It may also be necessary to take swipes on areas of equipment after surveys with portable alpha scintillators or GM detectors indicate elevated radiation readings. These samples will distinguish the difference between amounts of fixed and removable contamination. Swipes need not be taken on equipment that will be reused in a controlled area as long as workers are in adequate levels of protection and the equipment has been subjected to a general equipment decontamination.

2.1 HEALTH AND SAFETY GUIDELINES

All personnel will wear protective clothing as described in the Health and Safety Plan. In addition, all personnel will wear TLD badges and carry appropriate identification.

2.2 SWIPE EQUIPMENT CHECKLIST

______ Swipe pads

______ Sample holders or envelopes

______ Indelible marker

______ Latex gloves

______ Operational laboratory counting system, calibrated and with a low background, such as Ludlum model 43-1 or 43-5.

______ Alpha check source; Am-241 or Th-230 electroplated sources

3.0 PROCEDURES

3.1 PREPARATION

3.1.1 Office

A. Review the Health and Safety Plan and associated procedures.

B. Coordinate schedules/actions with project staff.

C. Checkout and ensure the proper operation of all field equipment (2.2)

D. Assemble a sufficient number of field forms to complete the field assignment (Appendix 5.1).

E. Arrange for laboratory counting system and personnel to perform desired radiological analysis of swipes.

3.1.2 Field

A. Label all swipe envelopes with date, location, time, and initials. Make sure a sufficient number of swipes are available for desired tasks.

B. If swipes are to be taken in a controlled area, wear appropriate protective clothing. Latex gloves are suggested for all types of sampling if acceptable with health and safety staff.

3.2 SAMPLE COLLECTION

A. Information describing swipe sampling activities shall be recorded on the Alpha Contamination Survey Data Form (Appendix 5.1). A completed form should contain the following information: site code or number, company and person taking swipes, date swipe taken, model numbers serial numbers and calibration information for the ratemeter/scaler and the alpha probe, and alpha probe efficiency.

$$\text{Efficiency} = \frac{\text{Gross CPM} - \text{Background CPM}}{\text{Source DPM}}$$

Probe face areas for Ludlum models 43-1 and 43-5 are given at the bottom of the Alpha Contamination Survey Data Form. The threshold refers to the adjustment for the lower energy level of the discriminator. It should be set as close to zero as possible, without picking up electronic noise. The high voltage setting is determined through a voltage plateau curve, or by the manufacturer. Both the threshold and high voltage settings are usually determined by routine equipment maintenance in the office.

B. Swipes shall be obtained from an area of 100 cm^2 when and where possible. Record results on the Alpha Contamination Survey Data Form. Note when not possible to obtain this area and make an estimate of the surface area (in cm^2) covered in the comments data field. (For convenience: 100cm^2 = 16 in^2.)

C. Use sufficient pressure on the swipe to pick up loose contamination without tearing or separating the swipe. Rough surfaces such as concrete, cast iron, and rough cut lumber may need to be surveyed for total contamination level, not removable.

D. Take swipe in a S-shaped pattern, if possible.

E. Swipe integrity should be maintained.

F. During routine swipe surveys, particular attention should be given to areas on equipment where the spread of contamination would be most likely (handles, footrest, etc.).

G. Caution must be exercised when obtaining samples from equipment with sharp edges to prevent injury.

H. Return swipe to properly labeled glassine envelope.

I. Give all swipes to laboratory personnel in charge of analyses as soon as possible.

3.3 POST OPERATION

3.3.1 Laboratory

A. Analytical results are to be recorded in a laboratory notebook and reported in units achieved with specific counting system.

B. Any swipes that exceeded the removable contamination limits for specific radionuclides shall be saved. Equipment failing to meet removable limits will be subject to a repeat of the general decontamination procedure for equipment.

C. Laboratory personnel must notify personnel in charge of release of equipment of any results that would not allow unrestricted release.

3.3.2 Field

A. Provide the onsite coordinator or the field team leader with copies of all Alpha Contamination Survey Forms (for removable contamination) for that day.

B. Decontaminate swipe equipment as necessary.

C. Return all equipment to storage area. Be certain ratemeter/scaler is in the "OFF" position.

D. Equipment failing to meet release criteria after repeated decontamination efforts must be held from unrestricted release.

3.3.3 Office

A. Return equipment to equipment manager and note any malfunctions or problems associated with its use.

B. Ensure that all radiological sources and standards have been stored in a locked area.

C. Review field forms for completeness.

D. File original forms and logbooks.

4.0 REFERENCES

AEC. 1974. "Termination of Operating Licenses for Nuclear Reactors." U.S. Atomic Energy Commission Regulatory Guide 1.86.

5.0 APPENDICES

5.1 ALPHA CONTAMINATION SURVEY FORM

APPENDIX 5.1

ALPHA CONTAMINATION SURVEY DATA FORM

ALPHA CONTAMINATION SURVEY DATA

SITE CODE ______________________ LOG DATE ______________________

LOGGER CODE ______________________ FIELD REP ______________________

RATEMETER/SCALER: ACCEPTANCE CODE ______________________

MODEL NO __________ SERIAL NO __________ CALIBRATION DATE __________

WINDOW OUT THRESHOLD __________ HIGH VOLTAGE __________ BATTERY __________

ALPHA PROBE:

MODEL NO __________ SERIAL NO __________ EFFICIENCY __________ CPM/DPM

PROBE FACE AREA[1] __________

COMMENTS ____

TOTAL ALPHA SURVEY			
ITEM SURVEYED (SPECIFY)	INSTRUMENT READING (CPM)	CALIBRATION FACTOR[2] (DPM/100cm^2)/CPM	CONTAMINATION LEVEL (DPM/100cm^2)/CPM

1 LUDLUM MODEL 43-1 PROBE FACE AREA = 50 cm^2
LUDLUM MODEL 43-5 PROBE FACE AREA = 75 cm^2

2 CALIBRATION FACTOR = (100/PROBEFACE AREA (cm^2))/EFFECIENCY(CPM/DPM)

ACCEPTANCE CODES: A-ACCEPTABLE M-MARGINALLY ACCEPTABLE R-RECONNAISSANCE U-UNACCEPTABLE N-NOT DETERMINED

FORM COMPLETED BY/DATE ______________________ TECHNICAL REVIEWER/DATE ______________________

OUTDOOR GAMMA SURVEYS/SCREENING

USING A SODIUM IODIDE (NaI) DETECTOR

1.0 PURPOSE

To measure the range of outdoor gamma exposure rates and to locate areas of elevated gamma activity with respect to a reproducible grid system so that soil sampling and downhole gamma logging locations can be determined.

2.0 DISCUSSION/APPLICATION

When correlated to pressurized ionization chamber measurements, exposure rate measurements with a NaI detector provide useful data on gamma radiation field strengths. The results of gamma exposure rate measurements are essential in determining the necessary radiation protection measures for a work area. Gamma radiation field strengths may also be used as an indicator of soil contamination by gamma emitters. Care must be taken in interpreting elevated exposure rate data since readings in uncontaminated areas can be high if they are adjacent to an area contaminated with gamma emitters.

Using this procedure, it is possible to identify area or point sources of gamma-emitting radionuclides and determine whether an observed reading is due to a shine from an adjacent source. These techniques are outlined in Sections 3.2.3B and 3.2.3C. It should be noted, however, that these are considered gross screening techniques rather than determine measures and cannot be interpreted to indicate specific radionuclide concentrations. The resulting product of an outdoor gamma scan is a surface gamma-isoexposure map of the property drawn to scale.

3.0 PROCEDURE

3.1 PREPARATION

3.1.1 Office

A Review site-specific Health and Safety Plan and any other site-specific documents and associated procedures.

B. Coordinate schedules/actions with project staff.

C. Checkout and ensure the proper operation of all field equipment (3.1.2). Ensure current calibration of probe and ratemeter/scaler.

D. Assemble a sufficient number of field forms to complete the field assignment.

E. Obtain PIC - NaI detector correlation data if it has been determined for the area to be surveyed.

3.1.2 Equipment Checklist

_______ Ludlum Model 2220 ratemeter or equivalent

_______ Ludlum Model 19 microR meter

_______ Ludlum Model 44-10 2" x 2" sodium iodide detector or equivalent

_______ Field logbook

_______ Cs-137 gamma check source

_______ Reuter Stokes - Model RS111 pressurized ionization chamber or equivalent

_______ Gamma Ray Exposure Rate Data Forms

3.1.3 Field

A. Visually inspect equipment, including connector cable for breakage.

B. Check battery charge; replace batteries if necessary.

C. Set THRESHOLD to the value given on the calibration sticker (usually 100 volts).

D. Set DETECTOR VOLTAGE to the value given on the calibration sticker (usually 1000 volts).

E. Set WINDOW to the out position (gross mode).

F. Note the response of the detector to the check source.

3.2 OPERATION

3.2.1 Health and Safety Guidelines

Personnel will wear protective equipment as described in the Health and Safety Plan. All personnel will wear TLD badges and carry appropriate identification.

3.2.2 Gamma Ray Exposure Rate Data Form

Gamma exposure-rate measurements with the NaI detector shall be recorded on the Gamma Ray Exposure Rate Data form, A copy of the form is supplied in Appendix 5.2; the form shall be completed with the following information.

1. Site Code. The code is assigned to the site subject under investigation.

2. Logger Code. Code identifying the company responsible for performing field measurements or collecting samples.

3. Log Date. The date when the exposure rate was measured.

4. Acceptance Code. One-character code distinguishing acceptability of data collected. The acceptance code is not determined by the field personnel, but instead, will be furnished by the individual who reviews the data provided on the form.

5. Field Rep. The name of the person completing the form.

6. Ratemeter/Scaler Model No. The model number of the ratemeter/scaler.

7. Ratemeter/Scaler Serial No. The serial number of the ratemeter/scaler.

8. Ratemeter/Scaler Calibration Date. The date when the ratemeter or scaler was calibrated.

9. Window. The window will be <u>out</u> for this procedure.

10. Threshold. The adjustment for the lower energy level of the discriminator. The threshold value shall be set to the value given on the calibration sticker.

11. High Voltage. The voltage that is applied to the detector. The high voltage value shall be set to the value given on the calibration sticker.

12. Battery. The battery charge reading at the beginning of the measurement.

13. Probe Model No. The model number of the probe.

14. Probe Serial No. The serial number of the probe.

15. Probe Calibration Date. The date when the probe was calibrated.

16. Check Source Serial No. The serial number of the check source.

17. Check Source Isotope. The radioactive isotope that the source contains.

18. Check Source Activity. The activity of the check source.

19. Source Check Meter Reading. The results of a count on a check source. The check source data consists of three fields: total counts, count time in minutes, and count rate in CPM. A source check should be performed daily during use.

20. Efficiency. The ratio of the observed count rate to the true disintegration rate of the check source.

21. Site Area Correlation No. The number assigned to the PIC - scintillometer correlation data set.

22. Correlation Equation. A linear equation used to convert from CPM to microR/hr.

23. Comments. Appropriate observations or information for which no other blanks are provided.

24. Coordinates. The coordinates of the measurement location in feet. The format is Northing (NORTH) and Easting (EAST).

25. Meter Reading. The count rate in counts per minute. There are two fields, one is for readings at ground level and the other is for readings at 3 ft.

26. Exposure Rate. The exposure rate in microR/hour. In order to make entries into these fields, it is necessary to know the count rate to exposure rate conversion factor for the area of the site as determined by comparison with a pressurized ion chamber. There are two fields, one is for readings at 3 ft and the other is for readings at ground level.

3.2.3 TAKING EXPOSURE RATE MEASUREMENTS FOR SURVEYS

A.

1. Layout a 10-ft square grid within the site boundaries that is tied into the baseline coordinate system. Other grid sizes may be used as designated.

2. Perform a preliminary ground surface and waist level scan with the scintillometer to identify areas of elevated outdoor gamma radiation and to determine the average outdoor gamma exposure rate.

3. Measure the outdoor exposure rates by contact readings at the ground surface at each grid intersection within the property boundaries. In areas of elevated gamma radiation, make additional scintillometer readings between grid points to define the extent of radiological contamination. Move the scintillometer in a slow, level arc to 4 or 5 feet above the ground surface accompanied by a forward step of 1 to 2 feet across each grid intersection point. Monitor the meter output on a continuous basis to identify peak exposures.

4. Record locations and levels where elevated readings were found on a site map. Record all readings on the Gamma Ray Exposure Rate Data Form.

5. Plot the results on a scaled map of the property with lines of equal exposure between grid measurements drawn by interpolation.

B. Recognizing Area and Point Sources

1. At the highest observed gamma-exposure rate, compare the count rate obtained at waist height with the count rate obtained at ground level.

2. If both count rates are above background and increase rapidly as the detector is held closer to the ground surface, the anomalous area may be an isolated hot spot with an area of only a few sq. ft.

3. If the highest observed gamma-exposure rate is broad in extent and there is no difference in exposure rate at ground level and at waist height, the anomalous area is not highly localized.

C. Recognizing Gamma Shine from Nearby Anomalies

1. Walk slowly in the area of interest, holding the NaI detector at waist height.

2. If the exposure rate increases as you leave the area of interest, some of the gamma-count rate observed at the area of interest may be due to shine from an adjacent gamma source.

3. If the exposure rate increases as the height of the detector above the ground increases, some of the gamma-count rate at the area of interest may be due to shine.

3.3 POST OPERATION

3.3.1 Field

A. Turn all switches to the OFF position.

B. Return all equipment to appropriate storage area after ensuring instrument power settings are in the "OFF" position.

C. Provide onsite coordinator with all copies of the Gamma Exposure Survey Data Forms.

3.3.2 Office

A. Return all field equipment to equipment manager and identify any operational problems or comments from previous use.

B. Ensure that all radiological sources and standards have been stored in a locked area.

C. Review field forms for completeness.

D. File original forms and logbooks.

4.0 REFERENCES

Manufacturer's Instrument Manual for the ratemeter/scaler.

Manufacturer's Instrument Manual for the NaI detector.

5.0 APPENDICES

5.1 GAMMA RAY EXPOSURE RATE DATA FORM

APPENDIX 5.1

GAMMA RAY EXPOSURE RATE DATA FORM

GAMMA RAY EXPOSURE RATE DATA
(USING SCINTILLOMETER)

PAGE 1 OF ___

SITE CODE ______________ FIELD REP ______________

LOGGER CODE ______________ LOG DATE ______________

ACCEPTANCE CODE ______________ SITE AREA CORRELATION NO ______________

RATEMETER/SCALER:

MODEL NO ________ SERIAL NO ________ CALIBRATION DATE ________

WINDOW ________ THRESHOLD ________ BATTERY ________

PROBE:

MODEL NO ________ SERIAL NO ________ CALIBRATION DATE ________

CHECK SOURCE:

ISOTOPE ________ ACTIVITY ________ DPM SERIAL NO ________

METER READING ________ COUNTS/ ________ MIN = ________ CPM

EFFICIENCY ________ CPM/ ________ DPM = ________ CPM/DPM

COORDINATES (FT)		METER READING (CPM)		EXPOSURE RATE	
NORTH	EAST	SURFACE	3 FT	SURFACE	3 FT

ACCEPTANCE CODES: A-ACCEPTABLE M-MARGINALLY ACCEPTABLE R-RECONNAISSANCE U-UNACCEPTABLE N-NOT DETERMINED

______________ FORM COMPLETED BY/DATE

______________ TECHNICAL REVIEWER/DATE

EXPOSURE RATE MEASUREMENTS USING A PRESSURIZED ION CHAMBER

1.0 PURPOSE

To ensure uniform measurement techniques when using a pressurized ionization chamber (PIC) for determining external gamma exposure rate at a height of 1 meter above soil or other surfaces.

2.0 DISCUSSION/APPLICATION

The PIC is one of the most accurate instruments for measuring gamma radiation exposure rates in the field. In addition to giving the exposure rate in a micro R/hour value, the PIC can also be used to field calibrate or standardize hand held gamma scintillometers, such as an NaI detector system. A PIC can be used indoors or outdoors, and can be used as a general survey instrument, or to isolate a radioactive source.

A PIC cannot be used to identify a specific radionuclide or to quantify a source in terms of a pCi/liter measurement. It can be used in the determination of personnel protection requirements, and in determining the need for further investigations or laboratory studies.

2.1 PROTECTIVE CLOTHING

Protective clothing will be worn as specified in the site specific Health and Safety Plan. In addition, all personnel will wear TLD badges and carry appropriate identification.

2.2 EQUIPMENT CHECKLIST

_______ Reuter-stokes pressurized ionization chamber (calibrated)

_______ Reuter-stokes PIC operational manual

_______ Stopwatch

3.0 PROCEDURES

3.1 PREPARATION

3.1.1 Office

A. Review the Health and Safety Plan and any associated procedures.

B. Coordinate schedules/actions with project staff.

C. Checkout and ensure the proper operation of all field equipment listed on the Equipment Checklist (2.2).

D. Assemble a sufficient number of field forms to complete the field assignment.

E. Ensure proper operation of the PIC according to instructions included in the operational manual and in this procedure.

3.1.2. Field

A. Assembly. The instrument should be assembled as follows.

1. Attach sensor head to tripod.

2. Adjust height of the chamber 1 meter from the surface to be measured.

   CAUTION: Ensure electrometer and mode switches are both in the OFF position.

3. Connect cable to readout housing.

3.2 OPERATION

A. The following steps should be taken before the initial measurement.

1. Turn display/recorder switch to ON.

2. Turn electrometer switch to zero.

3. Turn mode switch to BATT position.

4. Simultaneously depress the push-to-read switch (located below digital device) and the switch designated 300 V.

5. If the digital display shows less than 85 (as a % charge), replace 300 V battery per Operational Manual.

6. Check the charge on the -14 V, +14 V, and 12 V lead-acid batteries by depressing switch immediately below the voltmeters for each battery. If the need is on or near the shaded area of the meter, recharge these batteries before proceeding.

7. Perform a sourcecheck and compare the results with previous values.

B. For making measurements, follow the steps presented below.

1. Place the mode switch in the DC position.

2. Place the electrometer switch in the ZERO position, wait 60 seconds.

3. Place the electrometer switch in the READ position.

4. Turn the recorder ON.

5. Reset the mechanical counter and start the stopwatch simultaneously.

6. After 10 minutes, or until the counter integrates 1.0 microR, record elapsed time and exposure.

7. Determine exposure rate in microR/hr (uR/hr) using the following formula.

$$\text{Exposure rate (uR/hr)} = \frac{60\ \text{(min)}}{\text{(hr)}} * \frac{\text{exposure recorded by PIC (uR)}}{\text{count time(min)}}$$

C. Record the exposure rate along with the other information on the Exposure Rate Correlation Data Form, (Appendix 5.1). The Exposure Rate Correlation Data Form shall be completed as follows:

1. Site Code. This code is assigned to the subject under investigation.

2. Log Date. The date when the exposure rate was measured.

3. Logger Code. The code identifying the company responsible for performing field measurements.

4. Field Rep. The name of person completing the form.

5. Acceptance Code. Code distinguishing acceptability of data collected. This is determined by an individual who reviews the data recorded on the form.

6. PIC Calibration Date. The date when the PIC was calibrated.

7. PIC Model Number. The model number of the PIC.

8. PIC Serial Number. The serial number of the PIC.

9. PIC Battery Check. Were the battery voltage readings at the beginning of the measurement within the limits specified in Section 3.2A.

10. PIC Unit of Measure. The units in which the PIC reads. Most PIC instruments read in microR/hr; consult the

manufacturer's instrument manual to determine the measurement units.

11. Check Source Serial No. The serial number of the radiation check source.

12. Check Source Isotope. The radioactive isotope contained in the check source.

13. Check Source Activity. The activity of the radioactive check source, in disintegrations per minute (DPM).

14. Source Check Meter Reading. The results of a count on the check source. Source check data consists of three fields: total counts, count time in minutes, and count rate in counts per daily minute (CPM). A source check shall be performed on the PIC and all scintillometers used in the field.

15. Comments. Appropriate observations or information for which no other blanks are provided.

16. Coordinates. The coordinates of the measurement location in feet. The format is Northing (NORTH) and Easting (EAST). If coordinates have not been determined; a location code or description can be used here.

17. Integrated PIC Value. The PIC reading in the specified units.

3.3 POST OPERATION

3.3.1 Field

A. Turn electrometer and mode switches to the OFF position.

B. Return all equipment to their appropriate storage area after ensuring instrument power settings are in the "OFF" position.

C. Provide field team leader with all copies of the Exposure Rate Correlation Data Forms (Appendix 5.1).

3.3.2 Office

A. Return PIC and scintillometers to equipment manager and identify any operational problems or comments from previous use.

B. Ensure that all radiological sources and standards have been stored in a locked area.

C. File original forms and logbooks.

4.0 REFERENCES

Reuter-Stokes PIC Operational Manual.

5.0 APPENDICES

5.1 EXPOSURE RATE CORRELATION DATA FORM

APPENDIX 5.1

EXPOSURE RATE CORRELATION DATA FORM

EXPOSURE RATE CORRELATION DATA

PAGE 1 OF ____

SITE CODE ____	PIC:
LOG DATE ____	CALIBRATION DATE ____
LOGGER CODE ____	MODEL NO ____
FIELD REP ____	SERIAL NO ____
ACCEPTANCE CODE ____	BATTERY ____
SITE AREA CORRELATION NO ____	UNIT OF MEASURE ____

SCINTILLOMETER NO 1	SCINTILLOMETER NO 2
RATEMETER/SCALER: MODEL NO	RATEMETER/SCALER: MODEL NO
SERIAL NO	SERIAL NO
CALIBRATION DATE	CALIBRATION DATE
BATTERY	BATTERY
WINDOW	WINDOW
THRESHOLD	THRESHOLD
HIGH VOLTAGE	HIGH VOLTAGE
NAI PROBE: MODEL NO	NAI PROBE: MODEL NO
SERIAL NO	SERIAL NO
CALIBRATION DATE	CALIBRATION DATE
UNIT OF MEASURE	UNIT OF MEASURE

CHECK SOURCE:
SERIAL NO ____ ISOTOPE ____ ACTIVITY ____ DPM

SOURCE CHECK READINGS:
PIC ____ METER NO 1 ____ METER NO 2 ____

COMMENTS ____

COORDINATES (FT)		INTEGRATED PIC VALUE	SCINTILLOMETER VALUE	
NORTH	EAST		1	2

ACCEPTANCE CODES: A-ACCEPTABLE M-MARGINALLY ACCEPTABLE R-RECONNAISSANCE U-UNACCEPTABLE N-NOT DETERMINED

____ FORM COMPLETED BY/DATE

____ TECHNICAL REVIEWER/DATE

CORRELATION OF A SODIUM IODIDE DETECTOR TO THE PRESSURIZED IONIZATION CHAMBER

1.0. PURPOSE

To describe the method for correlating count rates obtained using a sodium iodide (NaI) detector and Ratemeter/Scaler to the exposure rate measurements taken with a pressured ionization chamber (PIC).

2.0. DISCUSSION/APPLICATION

By correlating scintillation-detector measurements with accurate PIC measurements on a site-specific basis, correction factors can be determined and applied to the scintillation detector measurements to evaluate gamma-exposure rates. This procedure permits the use of less expensive and less cumbersome portable instruments to obtain exposure rate survey data in terms of a micro R/hour value. The exposure rate values obtained can be used in determining personnel protection needs, as part of a general area survey, and in isolating a radioactive source.

2.1 HEALTH AND SAFETY GUIDELINES

Personnel will wear protective equipment, as described in the Health and Safety Plan. All personnel will wear TLD badges and carry appropriate identification.

2.2 EQUIPMENT CHECKLIST

_______ Sodium Iodide Scintillation Detector and Operations Manual

_______ Portable Ratemeter/Scaler and Operations Manual

_______ Connector Cable

_______ Reuter-Stokes PIC and Operations Manual

3.0. PROCEDURE

3.1 PREPARATION

3.1.1 Office

A. Review the Health and Safety Plan, and associated procedures.

B. Obtain materials listed in the equipment checklist (2.2).

C. Coordinate schedules/actions with project staff.

D. Check to ensure current calibration of all detection instruments.

E. The following steps should be performed on the PIC before departure to the field.

1. Turn DISPLAY/RECORDER switch to ON.

2. Turn ELECTROMETER switch to zero.

3. Turn MODE switch to BATT position.

4. Simultaneously depress the PUSH-TO-READ switch (located below digital display device) and the switch designated 300 volts (V).

5. If the digital display shows less than 85 (as a % of charge), replace 300 V battery per PIC operational manual or return the instrument to the factory for replacement. Check the charge on the -14V, 14V and 12V lead-acid batteries by depressing switch below the voltmeters for each battery. If the needle is on or near the shaded area of the meter, recharge these batteries before proceeding.

3.1.2 Field

A. Ensure proper operation of the NaI probe and ratemeter/scaler.

   1. Check HV, window, threshold, battery.

B. Assemble the PIC per operational manual.

   1. Attach sensor head to tripod.

   2. Adjust height of the chamber to 1 meter from the surface to be measured.

   3. CAUTION Ensure electrometer and mode switches are both in the OFF position.

   4. Connect cable to readout housing.

3.2 OPERATION

A. The Exposure Rate Correlation Data Field Form, (Appendix 5.1), shall be completed as follows.

   1. Site Code. The code is assigned to the subject under investigation.

   2. Log Date. The date when the measurements were made.

   3. Logger Code. Code identifying the company responsible for performing field measurements or collecting samples.

   4. Field Rep. The name of the person completing the form.

5. Acceptance Code. Code distinguishing acceptability of data collected. It is determined by an individual who reviews the recorded data.

6. Site Area Correlation No. More than one set of correlations of PIC and scintillometer data may be required for a given site. The Site Area Correlation Number is a number to be assigned prior to field work. Enter "none" if the PIC data is not being correlated with scintillometer readings.

7. PIC Calibration Date. The Date when the PIC was last calibrated.

8. PIC Model No. The model number of the PIC.

9. PIC Serial No. The serial number of the PIC.

10. Battery. The battery voltage read at the beginning of the measurement.

11. PIC Unit of Measure. The unit in which the PIC reads. Most PIC instruments read in microR/hr; consult the manufacturer's instrument manual to determine the measurement units.

12. Ratemeter/Scaler Model No. The model number of the ratemeter/scaler.

13. Ratemeter/Scaler Serial No. The serial number of the ratemeter/scaler.

14. Ratemeter/Scaler Calibration Date. The date when the ratemeter/scaler was last calibrated.

15. Window. Set the window per the instructions of the project a field supervisor.

16. Threshold. The adjustment for the lower energy level of the discriminator. Instructions for setting the threshold will be supplied by the project or field supervisor.

17. High voltage. The voltage that is applied the detector.

18. Probe Model No. The model number of the probe.

19. Probe Serial No. The serial number of the probe.

20. Probe Calibration Date. The date when the probe was last calibrated.

21. Check Source Serial No. The serial number of the radiation source.

22. Check Source Isotope. The radioactive isotope that the source contains.

23. Check Source Activity. The activity of the radioactive source.

24. Check Source Reading. The results of counts on a check source.

25. Comments. Appropriate observations or information for which there are no other blanks.

26. Coordinates. The location of the measurement spot on the survey grid in feet. There are two fields, one is for the North coordinate and one for the East coordinate. If coordinates have not been determined, a location code or description can be used.

27. Integrated PIC Value. The PIC reading in the specified units.

28. Meter. The scintillometer reading. There are two fields, one for scintillometer no. 1 and one for scintillometer no. 2 (if 2 scintillometers are to be used).

B. The correlation is performed using 5 to 20 locations ranging in activity from normal background to the maximum level of gamma exposure found at the site. There may be several areas where these correlations will be performed. It may be necessary to subdivide a site into regions where, within the region, there should not be a varied photon spectrum. The measurement locations should be chosen so that the exposure rate does not vary with slight differences in positioning of the two detectors. Measurements shall be taken alternately at each location with both instruments at approximately 3 ft off the ground. Results shall be recorded on the Site-Specific Exposure Rate Correlation Data Form (Appendix 5.1).

C. After performing measurements at a sufficient number of locations, the readings from both instruments will be correlated using a least square regression. The regression equation will have the form:

$$E = a(Em) + b$$

where,

E is the PIC reading in micro R/hr.

a is the slope of the line,

Em is the scintillation reading in counts per time interval,

b is the Y-axis intercept.

The correlation coefficient and confidence limits for the fit will be calculated for future reference.

3.3 POST-OPERATION

3.3.1 Field

A. Decontaminate all equipment as necessary.

B. Replace PIC in the carrying case after making certain power switches are in the OFF position.

C. Return portable gamma detector to appropriate storage area.

3.3.2 Office

A. Return all field equipment to equipment manager and describe any malfunctions or problems with equipment.

B. File original data forms.

4.0 REFERENCES

Reuter-stokes PIC Operational Manual.

Ratemeter/Scaler Operational Manual.

5.0 APPENDICES

5.1 EXPOSURE RATE CORRELATION DATA FIELD FORM

APPENDIX 5.1

EXPOSURE RATE CORRELATION DATA FORM

EXPOSURE RATE CORRELATION DATA

PAGE 1 OF ____

SITE CODE ____________ PIC:

LOG DATE ____________ CALIBRATION DATE ____________

LOGGER CODE ____________ MODEL NO ____________

FIELD REP ____________ SERIAL NO ____________

ACCEPTANCE CODE ____________ BATTERY ____________

SITE AREA CORRELATION NO ____________ UNIT OF MEASURE ____________

SCINTILLOMETER NO 1	SCINTILLOMETER NO 2
RATEMETER/SCALER: MODEL NO	RATEMETER/SCALER: MODEL NO
SERIAL NO	SERIAL NO
CALIBRATION DATE	CALIBRATION DATE
BATTERY	BATTERY
WINDOW	WINDOW
THRESHOLD	THRESHOLD
HIGH VOLTAGE	HIGH VOLTAGE
NAI PROBE: MODEL NO	NAI PROBE: MODEL NO
SERIAL NO	SERIAL NO
CALIBRATION DATE	CALIBRATION DATE
UNIT OF MEASURE	UNIT OF MEASURE

CHECK SOURCE:
SERIAL NO ____________ ISOTOPE ____________ ACTIVITY ____________ DPM

SOURCE CHECK READINGS:
PIC ____________ METER NO 1 ____________ METER NO 2 ____________

COMMENTS ____________

COORDINATES (FT)		INTEGRATED PIC VALUE	SCINTILLOMETER VALUE	
NORTH	EAST		1	2

ACCEPTANCE CODES: A—ACCEPTABLE M—MARGINALLY ACCEPTABLE R—RECONNAISSANCE U—UNACCEPTABLE N—NOT DETERMINED

____________ FORM COMPLETED BY/DATE

____________ TECHNICAL REVIEWER/DATE